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HÆMANGIOMA OF THE SPINAL CORD

ASSOCIATED WITH SKIN NÆVI OF THE SAME METAMERE*

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HÆMANGIOMATA of the spinal cord and its membranes are rare, and in the published lists of cord tumors no record is found of their occurrence (viz., Schlesinger's list [15] of 400 cases and Flateau's [14] of 213). A thorough review of the literature, however, brings to light seven cases beside the one here reported.

GAUPP,[1] in 1887, describes two cases in an inaugural dissertation embodied in *Ziegler's Beiträge* for that year. The first has no clinical history, and tells of the finding at autopsy of an angioma on the cauda equina measuring three by two cm.; above this point in the cord were two neurofibromata, and a glioma with syringomyelia in which was a fresh hemorrhage. He considers that these three different tumors each arose from an embryonal defect in the cord.

His second case [2] is more interesting and gives the history of a woman of forty-five who had a condition diagnosed as "spinal meningitis" at twenty-one, followed by weakness of her legs, and paræsthesia slowly increasing for ten years; during the next four years she could limp about, and then both legs suddenly became spastic and anæsthetic with motor and vasomotor paralysis, and incontinence of urine and fæces. This condition improved a little during the next few months, but for ten years more she was a cripple and finally died of decubitus infection. The post-mortem examination showed a widening of the spinal canal in the lower dorsal and upper lumbar vertebræ, with a large varix of veins arising from the pia which pressed upon and flattened the spinal cord.

The next case reported is one by BERENBRUCH,[3] in 1890, in another inaugural dissertation, at Tübingen. This patient, a boy of sixteen, was born with lipomata showing on his left side over the pectoralis muscle, on the right scapula, and along the latissimus dorsi on the right; these increased in size as he grew older, and at the time of the onset of the paralysis were quite deforming, the one on the right scapula being as large as a boy's head, and the one over the latissimus dorsi, though less prominent, made that whole side of his back appear enlarged. One day after severe exercise he felt weak and tired in his legs; this persisted, and he had lancinating pains down both legs; at the end of two weeks he was entirely paralyzed in the right leg and partially in the left, with increased tendon reflexes and clonus. Sensory perception was dulled, but not lost, up to the middle of the abdomen. A diagnosis of lipoma in the spinal canal was made, and he was operated on two and a half months after the onset of the disease,

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but the three-hour operation exhausted him, and death followed in four hours. Autopsy showed that beside the three superficial lipomata, there was a large cavernous plexus of veins along the spinal column connecting with the two tumors of the back outwardly, and with an angioma of the dura by way of the intervertebral foramina. Furthermore, there was an angioma of the cord substance itself extending from the fifth cervical to the third dorsal segment, and in parts of this were extravasations of blood. Lastly the capsule of the right kidney showed a small angioma. All of these vascular tumors were made up of large and small blood-vessels; the external ones were mixed with fat, the dural with connective tissues, while the cord tumor was a pure hæmangioma.

In 1895 GERHARDT[4] reported a case in great detail. The patient was a man of eighteen; his first symptoms were weakness of the right foot and lower leg, followed eight days later by weakness of the left; "cramps" were then felt in both legs for a few days, while the weakness spread upwards until the whole of both legs was involved and walking became impossible. It was then found (four weeks after the onset) that anæsthesia was present up to the knees. Two months later the paralysis was total in both legs with loss of vesicle and sphincter control, and six months after the onset, hypæsthesia and paræsthesia extended up to the level of the navel; the knee and ankle jerks became exaggerated, and contractures developed in the leg muscles, with a thoracic scoliosis and lumbar kyphosis. For the next two years there was little change except that the hypæsthesia became total anæsthesia and the contractures increased. During the third year the joints became ankylosed, and in the fourth year the deep reflexes were lost. Finally erysipelas developed from a decubital ulcer, and he died in the sixth year of the disease. At autopsy a vascular tumor, diagnosed by von Recklinghausen as angioma, was found pressing on the cord at the level of the fifth and sixth thoracic vertebræ.

HARMAN AND BALK[5] reported a case in 1900. This was another long drawn-out story of a man who began by having pain in his legs, this lasted four or five months and then the pain suddenly increased, he lost motor power in his legs and opisthotonus developed. These symptoms gradually passed away in six months. Two years later he had a similar attack, but at the end of five months he was able to walk, though lame. His third attack came two and a half years later, and was at first slight, only interfering with locomotion for two weeks, but then, while in bed one day, he had a sudden great pain with retraction of the head, followed by difficulty in swallowing and articulation; later his sphincters became paralyzed, and in ten days he was dead. Autopsy showed a large blood clot in the spinal canal overlying the lumbar cord where there was found a cavernous angioma of the pia.

A year later LORENZ[6] had a case in Jena: a woman of twenty-seven, who first noticed weakness of her left hand. Two days later she suddenly collapsed with a sensory and motor paralysis of both legs, partial in both arms, and in a few hours her breathing became labored and she died two and a half days after the onset of the first symptom. The post-mortem examination disclosed an angioma of the pia, about the size of a cherry, at the level of the seventh cervical root, and a hemorrhage into the arachnoid space and cord substance from the first cervical to the fifth dorsal root.

The last case is one reported in 1903 by HADLICH.[7] This, like the first of the series, was an accidental autopsy finding. A woman of thirty-five, dwarfed and with a narrowed pelvis, died after Cæsarean section. At autopsy an angioma of

the pia was found in the lumbar region; it invaded the cord substance somewhat and caused marked distortion, but no hemorrhage was present.

CASE HISTORY.—E. A. P., an eight-year-old boy of Swedish extraction, entered the medical service in the Children's Hospital on May 23, 1914. Previous to the onset of the present illness, he had had a rather varied medical career; he was a full term, normally delivered child, well and vigorous during his first year. He then had measles, followed six months later by typhoid with bloody diarrhœa; during his convalescence, he sprained his right knee and was lame for a month, and then, at two years of age, he developed pertussis. During his third year he was well except for an enlarged lymph-node behind the angle of his right mandible, which disappeared without operation after several weeks. When he was four years old, he suddenly screamed with pain, complaining of his lower abdomen, and on examination a hernia was found in the left inguinal region, which was reduced with chloroform; for this he wore a truss for a year, and there has been no recurrence. From this time until he was eight years old, he enjoyed a healthy, normal boyhood.

Present Illness.—On May 15, 1914, he was suddenly stricken, while playing ball, with a sharp pain in his lower back, causing him to cry out. He was taken home feeling weak and nauseated, but without fever. He vomited once during the night after taking some medicine, but the main symptom was pain in the back, radiating into the lower abdomen. In a few hours this had subsided, but he did not feel well for the next four days, and was kept out of school. He then returned to school, apparently well, but three days later a similar sudden pain in the back attacked him, more severely than the first time, and for several hours he screeched and rolled about in agony. As this severe attack subsided, he said that the left foot felt numb, "as if it was asleep," and this gradually spread up the leg to the thigh, and then "down the other leg," till at the end of fourteen hours both lower extremities were numb and paralyzed. It was noted definitely that the left leg first became numb, but in which leg the paralysis first appeared is not known. The next morning it was found that the anal and vesicle sphincters were also paralyzed, there being incontinence of fæces and retention of urine, necessitating catheterization. On this day, May 23, eight days after the onset, he entered the Children's Hospital, with a presumptive diagnosis of anterior poliomyelitis.

Physical Examination.—This showed a flaxen-haired, blue-eyed boy well nourished and well developed, with a deep depression at the lower end of the sternum, and a birth-mark of the "port wine" variety on the left back. The neck was held stiffly and was perhaps slightly tender. The abdomen was also held

stiffly, but the liver edge was palpable, and a mass above the pubes, evidently a distended bladder. Both legs showed a complete flaccid paralysis, with absent knee-jerks, and no ankle clonus, Babinski, or Kernig.

Sensory examination revealed analgesia up to the level of the umbilicus, and anæsthesia except for the soles of the feet, where a sharp pin prick was felt dully. The abdominal reflexes were absent, and the cremasteric were sluggish. There was incontinence of urine. A lumbar puncture was done, and 40 c.c. of spinal fluid were withdrawn under increased pressure, showing twenty cells per cubic millimetre, 85 per cent. of which were

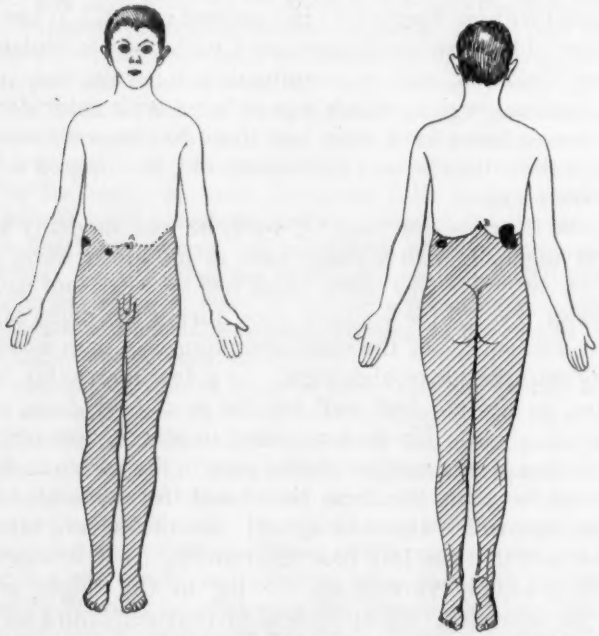

FIG. 2.—Diagram showing area of anæsthesia and position of nævi. *A*, umbilicus; *B*, spinous process of first lumbar vertebra; ■, nævi; ///, anæsthesia area.

mononuclear, and 15 per cent. polymorphonuclear. A von Pirquet skin test was positive in twenty-four hours; the leucocyte count was 15,000, and hæmoglobin (Sahli test) was 82 per cent.

Course of Symptoms.—For the first six weeks the paralysis was of a flaccid type, so the supposition that the disease was poliomyelitis was a natural one. Priapism was first noted on June 1, and persisted until after the operation. Then on July 3, a slight return of the knee-jerk in the right leg was noted; this leg was less flaccid and did not seem to fall so limply as previously. On July 4, stimulation on the soles of the feet caused flexion of the knees and ankles, and on the sixth the right knee jerk was ex-

FIG. 1.—Photograph six weeks after operation, showing upper level of anæsthesia (dotted line) crossing lower portion of nævus, and operative incision (between crosses).

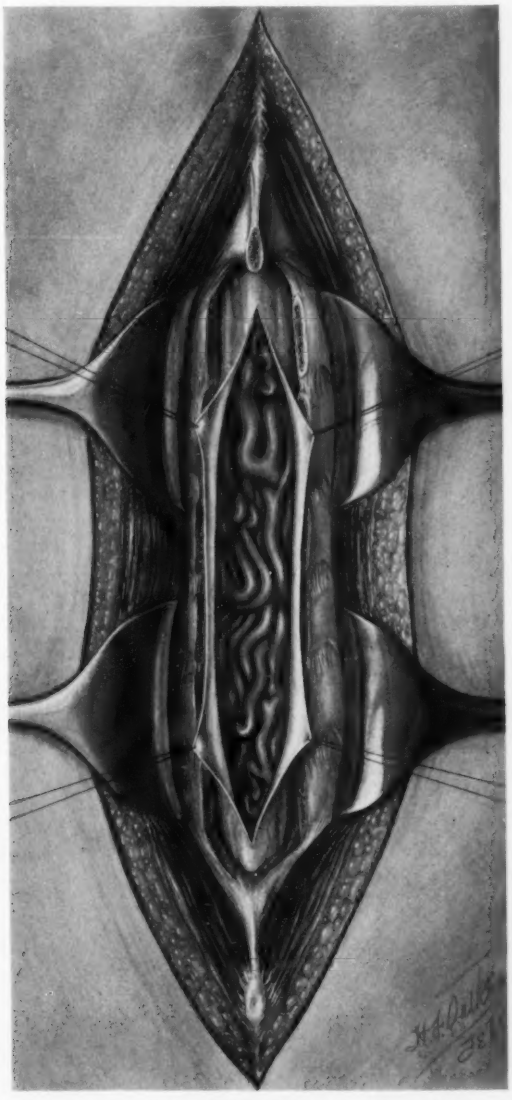

FIG. 3.—From sketch made at operation, showing incised dura with hæmangioma beneath (about one-half natural size).

aggerated, and ankle clonus was obtainable on the right, appearing on the left two days later.

On August 4, Oppenheim and Babinski reactions were found in both legs, the paralysis thus becoming completely and typically spastic ten and a half weeks after the first paralysis developed. During this time there was no return of voluntary muscle power or sensation, the anæsthetic area still extending up to the umbilicus. A swelling along the right side of the vertebral column from the fourth to the eighth dorsal vertebra was noted on September 17, but an X-ray of the chest was negative.

He was transferred to Professor Lovett's service on September 21 with a diagnosis of spinal cord tumor, and the following notes were recorded: "As he lies in bed the spine shows quite a marked right dorsa-lumbar scoliosis, and the ribs on the right side, posteriorly, between the scapula and spine, are more prominent than on the left. The patient is unable to sit or stand on account of loss of power of the supporting muscles of the back and abdomen. The trochanters are very prominent, with atrophy of the gluteal muscles. The Achilles tendons on both sides are contracted, holding the feet in moderate equinus. The Wassermann reaction on the blood is negative." On an exchange visit, soon after this, the patient was seen by Dr. Cushing, who ventured a diagnosis of congenital dermoid or hæmangioma; he based this on the fact that the skin nævus on the child's back lay in the same metamere as the presumed tumor of the spinal cord (Fig. 1).

On October 16, the patient was transferred to the surgical service at the Peter Bent Brigham Hospital. The neurological and general physical examinations here revealed nothing new, except that three more small nævi were noted about the trunk at the level of the umbilicus. The epigastric reflexes were present, but the abdominal and cremasteric were absent. The knee-jerks were hyperactive, ankle clonus was present on both sides, and Babinski, Oppenheim, and Gordon reactions were all obtained in both legs, but more markedly in the left. The sensory disturbances showed no change, anæsthesia extending up to the umbilicus anteriorly, to the tenth rib laterally, and posteriorly to the level of the first lumbar vertebra (Fig. 2). It was, however, noted that the toes showed some sense of position, more in the left foot than in the right. The urine was cloudy and showed many pus cells and a slight trace of albumen; the leucocyte count was 19,000; the hæmoglobin was 80 per cent.; the pulse ranged from 80 to 120, and the temperature from 98° to 100.2° Fahrenheit.

Dr. Cushing's note on the day of operation follows:

" This child shows a transverse paraplegia with the upper level of anæsthesia about at the tenth thoracic level. It has been presumed, owing to the acute onset of symptoms, that the case was

one of poliomyelitis of an unusual type. However, the definite upper level of anæsthesia, the complete lower limb paralysis with exaggerated reflexes, visceral paralysis, and priapism, make it fairly definite that there must be pressure against the cord. Examination shows a slight scoliosis with prominence of the spinal muscles at the scapula level, and over the lower portion of the right scapula there is a nævus about 5 inches in diameter. The presumptive diagnosis is of a congenital lesion pressing upon the cord, either a dermoid or an angioma. Similar meningeal angiomata have been observed by myself in association with facial nævi."

Operative Note.—October 30, 1914. *Exploratory laminectomy. Angioma.* "A long median incision was made with removal of the laminæ, possibly from T6 to T10 inclusive. The exploration was simple and dry. The exposed dura was bulging, and it was the operator's impression that the canal was much wider than usual, particularly for a thoracic region, and that the laminæ were unusually broad, flat, and thin.

"The exposed dura was tense, bulging, and transmitted an unusually dark subdural coloration. Fortunately great pains were taken to enter the dura without injuring the arachnoid, for a careless entrance would certainly have injured some of the enormous vessels which were disclosed on opening the meninx. Such of the arachnoid membrane as could be identified was more or less adherent to the dura by fine adhesions which readily broke down as the dura was drawn to each side. This exposed an extraordinary tangle of huge pulsating vessels filling the canal (see Fig. 3). It was possible in a few places to see the normal coloration of a very flattened spinal cord, through and below the meshwork of vessels.

"It seemed futile to attempt to ligate any of the vessels, and the dura was therefore left widely open, and the wound closed as usual in layers, without a drain."

The patient made a good ether recovery, but had a very uncomfortable convalescence. Careful watch was kept of the sensory disturbances, but no definite improvement was noted at any time. Three days after operation the priapism was still present, but on the fourth it disappeared, and has not returned. This is, unfortunately, the only symptom relieved by operation, the spastic paralysis, incontinence, and anæsthesia remaining. Some slight sensory changes appeared from time to time. At first the level of response to a heavy pin prick seemed to spread down the right leg as far as the groin, anæsthesia for light touch remaining at the level of the umbilicus; the muscle sense in the toes seemed to be more acute, and he could tell quite well in what position his toes were placed. On November 22 it was noticed that the right foot

was definitely colder than the left, and this condition continued until about December 14. On January 26 a spontaneous fracture of the femur occurred, and an X-ray showed extreme atrophy of the bones. So as time wore on, and no recovery seemed possible, it became a struggle against decubitus and cystitis.

A neurological examination on April 16 showed no change, except that there was a band of hyperæsthesia at the upper limit of the anæsthesia, and on the right a segment within the area of protopathic anæsthesia, where light touch could be felt. At the present writing (June 15) the patient is at home in unchanged condition.

Discussion.—This series of seven cases, though small, permits of a comparison which brings out some points of interest. The onset is usually slow, the paralysis not reaching its maximum for days or even months. In two instances, weakness of the feet was the first symptom, preceding paralysis of the legs by two weeks and by six months; in another, weakness of the right hand preceded the paralysis by two days. In three of the cases pain came on suddenly but was not followed by the paralysis for five days in one, two weeks in another, and five months in the third. A history of recurrent attacks after partial recovery appeared twice, while in four of the cases a single attack seemed sufficient to cause a permanent paralysis. Four of the histories note an onset with flaccid paralysis, described as "weakness," the spastic symptoms not coming on for a considerable time—two months, six months, and fourteen years in three of these, while in the fourth the patient died in the flaccid state. In short the symptomatology appears to be that of hemorrhage into the spinal cord or canal, generally recurrent if the patient survives the first paralysis. Death in two of the cases was due to respiratory failure, in two to decubitus, and in two others to operation, while one has no clinical history, and the other patient is alive at the present writing.

Pathologically it is striking that in all of the cases the tumor involved the pia; in two the dura was also involved, and in two the cord substance was invaded. The level of the angiomata on the cord is variable; three were lumbar, one cervical, one cervicodorsal, two dorsal, and one was found on the corda equina. The tendency seems, therefore, to be towards a low position. In two of the cases there was widening of the vertebral canal in the region of the tumor.

One of the most interesting features of the case here reported is the occurrence of nævi on the skin in the same metamere as the angioma of the cord; that is to say, the membranes of the spinal cord in the vicinity of the tumor are supplied by the same nerve roots as the skin on

which the nævi are found. In none of the other cases was a similar observation made, unless the lipomata and deep angiomata in Berenbruch's [8] case may be so considered, but nævi may have been present and escaped notice, or may have been noticed and not thought worthy of record. In searching through the literature on nævi, one case [8] is found where a large angioma of the right flank, in the sensory distribution of the eleventh dorsal segment, was associated with atrophy of the right leg; since this is the opposite of the usual condition of hypertrophy found with angiomata of the skin, it is possible that here is a case where an associated tumor was pressing on the lower dorsal cord; this is only hypothesis, however, as no autopsy was performed. Although no literature is obtainable on the association of nævi with cord tumors, an article by Cushing,[9] in 1906, entitled "Cases of Spontaneous Intracranial Hemorrhage Associated with Trigeminal Nævi," throws much light on the subject. He cites three cases observed by himself, and three other cases found in the literature, where facial nævi were associated with vascular tumors of the cerebral meninges; another case reported by Kalischer,[10] in 1901, brings the total up to seven. Skin nævi have also been found in association with angioma formation in the liver,[11] and in Berenbruch's case,[8] an angioma of the kidney capsule was present.

The subject of the metameric distribution of nævi has been taken up by numerous writers of the French School. Bärensprung,[12] in 1863, made the original communication, describing the topographical distribution of nævi and drawing attention to their development in definite connection with territories of cutaneous innervation. He believed the lesion to be a congenital one of the spinal ganglia because the cutaneous alteration consists in a hypertrophy of the elements in which the peripheral nerves terminate, *i.e.*, the pigmented layer of the skin where the free nerve endings lie, and the blood-vessels of the papillary layer which also receive nerve filaments. Etienne, in 1897,[13] took up the subject thoroughly, and came to a similar conclusion: that a nævus represents an intra-uterine nerve lesion. No one suggested, however, that organs other than the skin, but in the same segment of nerve distribution, could be similarly affected, until the publication of Cushing's article,[9] in 1906. The case in hand seems to substantiate this view, since it shows its application to nerve distributions other than the trigeminal, for in this case, four nævi were found on the skin, three on the right and one on the left side, in the cutaneous area supplied by the seventh, eighth, and ninth dorsal segments, and at operation the vascular tumor was seen to overlie the cord from its fourth to ninth

segment, while the upper limit of anæsthesia is at the level of the ninth dorsal segment. As only an operative incision was made, it is impossible to tell whether or not the angioma extended farther up and down the cord, but from the symptoms it is evident that the main lesion—probably a hemorrhage—was at the ninth dorsal level.

Conclusions.—(1) Skin nævi are at times of diagnostic value when segmental phenomena referable to the central nervous system are present.

(2) Congenital blood-vascular tumors apparently arise from a developmental fault of the central nervous system, so these lesions may occur in any of the organs innervated by filaments from that neuromere.

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THE CONSERVATIVE TREATMENT OF INTRINSIC CANCER OF THE LARYNX BY THYREOCRICOTOMY (TOTAL LARYNGOFISSURE) OR THYROTOMY (PARTIAL LARYNGOFISSURE)

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The treatment of malignant growths in regions where the lymphatics are abundant and lymphatic drainage territories ill defined, has shown in recent surgery two distinct tendencies: one to a radicalism that is disabling, the other to a conservatism that is merely palliative. The *former* tendency is well illustrated by the so-called block dissections, in which, for cancer invading the tongue, it is recommended to remove that portion of the inferior maxilla and floor of the mouth contiguous to the site of the lingual lesion, and, in addition, all the glands in one, sometimes both sides of the neck. This is a serious operation, the disfigurement after healing is severe and distressing, and often both surgeon and physician are disappointed to find the growth has recurred in the scar or in some lymphatic node that has escaped observation or is inaccessible. The *latter, i.e.,* the conservative course, is adopted by many surgeons who feel that, in tongue cancer, for instance, if the disease cannot be removed with a fair degree of thoroughness by an operation of moderate extent, it is better to attempt none or only palliative surgical measures.

The treatment of cancer of the larynx will follow one or the other of these courses, depending on whether the disease is extrinsic or intrinsic. In *extrinsic* cancer (Fig. 1), *i.e.,* growths located on the interarytenoid space, aryteno-epiglottic folds, epiglottis, or pyriform fossæ, the disease spreads rapidly, metastases occur earlier, and for their radical removal a complete laryngectomy after the method of Glück or some modification of that method is demanded. This operation is severe, crippling, destroys the voice, and is comparable to the block dissections referred to. While recurrences frequently follow, still the results in complete laryngectomy appear to be much better than those following operation of the tongue, for example; due in part, at least, to the fact that cancers of the larynx soon give evidence of their presence by definite symptoms relating to the voice or swallowing. Further, they are watched by skilled specialists and detected in their incipient

stages, while mouth, tongue and cheek cancers aften remain under the care of the family practitioner or are for some time disregarded entirely. Most important, however, is the lymphatic distribution, to be referred to later, which is so arranged that for a long time complete removal is possible.

Intrinsic cancer, on the other hand (Fig. 1), *i.e.*, cancer located on the true or false cords or somewhere below that level, is amenable to comparatively simple surgical procedures without great crippling and with a certainty of cure that surpasses cancer in almost any other situation—facts first demonstrated by Butlin and Semon, and more recently by an increasing number of observers with almost constantly improving statistics.

It is the purpose of this short paper to restate and emphasize the value of conservative surgery in the treatment of these *intrinsic* cancers, to point out that the work may be undertaken by the general surgeon in conjunction with the laryngologist, to briefly describe the steps of the operation and to report several cases illustrating the good results that may be expected.

The *lymphatic* vessels (Figs. 2 and 3) and nodes of the larynx, which, no doubt, play a most important part in the dissemination of cancer, are described by Most as follows: The network of lymphatic vessels in the larynx is separated almost entirely into a supra- and subglottic area by a horizontal non-vascular streak, a sort of *lymph-shed*, following the vocal folds (cords) (see Fig. 2). The only lymph-vessels connecting the two areas are those forming a rather rich network in the mucosa of the posterior laryngeal wall.

The supraglottic lymphatic area is somewhat richer than the subglottic, being more fully developed in the ventricle of the larynx and upon the ventricular folds (false vocal cords) than elsewhere. Above it is continuous with the lymphatic network of the epiglottis; below it is continued into the subglottic area by means of the vessels in the mucosa of the posterior laryngeal wall. The network becomes very scanty upon the upper surface of the vocal folds and upon their free margins is lost altogether.

The subglottic lymphatic area consists of more delicate vessels than the supraglottic, although, in general, the meshes are somewhat closer. Below it is continuous with the tracheal lymphatics; above it is continued posteriorly into the supraglottic area, but latterly it is lost at the summit of each vocal fold.

From the supraglottic lymphatic area, three to six efferents pass from the lateral region of the epiglottis at the aryepiglottic folds. These

pass through the hyothyroid membrane, and, reduced in number by coalescence, follow the superior laryngeal artery and cross the external carotid. They join the group of deep cervical glands situated on the common facial and internal jugular veins, or upon the thyroid gland. Some of the vessels occasionally pass *via* glands placed upon the intermediate tendon of the digastric, or at the lateral margin of the thyreohyoid muscle.

From the subglottic area, the vessels emerge in two sets: from the anterior subglottic area a few fine vessels pass through the conus elasticus (cricothyroid membrane) either in the midline, or laterally accompanying the inferior thyroid artery. The lymph from these eventually enters the deep cervical glands. The first vessels go to a pre-tracheal gland lying upon the conus, from which efferents may pass to a lower pre-tracheal gland and from the lower (when present), to a gland situated about the middle of the internal jugular vein, and to another pre-tracheal gland below the isthmus of the thyroid.

From the posterior subglottic area three to six vessels pass below the cricoid cartilage through the cricotracheal ligament. The vessels from this area accompany the recurrent laryngeal nerve and reach a chain of peritracheal glands which extend from the cricotracheal ligament along the posterior margin of the thyroid gland. In one case, Most found a vessel passing to the pre-tracheal gland upon the thyroid isthmus.

Thus intrinsic cancer remains for a long time confined to the inner surface of the organ, because of the scanty lymphatics and the restraining influence of the cartilages. The vessels do not enter these cartilages but are directed by them through the intercartilaginous membranes; thus there is slow absorption. When lymphatic drainage does take up the new growth, it follows certain lines, invades definite nodes, and, although it becomes extrinsic, there is still great good to be expected from the more radical operations.

Apart from the influence of the lymphatics, it is held by some that intrinsic cancer of the larynx is essentially a slow growing neoplasm.

It is important, in order to obtain the best results, that an early and definite diagnosis be made, and this can be done only by one thoroughly skilled in the use of the laryngeal mirror, and in the removal, by intralaryngeal methods, of portions of the growth for microscopic examination. When the growth is on the centre of the cord, as it is in more than one-half the intrinsic cases, the diagnosis is easy enough, but when it is under the cord, it can with difficulty be seen, its extent cannot be ascertained, and it is also difficult to remove a satis-

factory piece for examination. It is then probably better to do a thyrotomy, remove the growth, and afterward make certain of a diagnosis, than to wait until the case has become extralaryngeal. In my cases, diagnoses were all made by Drs. Coakley and Chisholm, the former taking specimens for examination in each case.

TECHNIC OF THE OPERATION

Many operators advise local anæthesia. In one of the cases reported herewith, it was utilized for the preliminary tracheotomy, further operation being continued under chloroform administered through the tracheal cannula; in the other two, chloroform was administered from the outset. One of the advantages of local anæsthesia is that during the operation the sensibility of the larynx is in some degree obtunded, reflex acts of coughing are lessened, and, following the operation, the conduction of pain to the central nervous system is controlled, a point worthy of consideration, since the shock of handling laryngeal tissues, particularly those above the vocal cord, is great. However, to have the sensibilities too much blunted is never an advantage, because of the danger of an aspiration pneumonia, one of the most frequent and serious complications following laryngeal operations. Even when general anæsthesia has been used, it is easy to spray or swab the larynx or pharynx with a four per cent. cocaine-adrenalin solution to prevent the reflex acts of coughing and vomiting which so disturb the conduct of the operation. This can easily be done in general anæsthesia after the thyroid has been opened, is not likely to be carried too far, and should permit the return of sensibility as soon as bleeding has been controlled, or as soon as the thyroid cartilage has been closed, until which time the patient should be kept with the head low to prevent aspiration into the lung.

Some operators prefer general anæsthesia, using chloroform, particularly in elderly people where it is feared to raise the blood-pressure, and on account of the lesser bleeding. In neurotic people there is no more objection to general anæsthesia than in any other condition. Besides, the presence of the tracheal tube allows one to tampon above the tube and thus prevent the entrance of blood into the lungs in a more effective way than can be done under local anæsthesia.

Tracheotomy should be performed as a preliminary, either several days preceding—thus making it a two-session operation—or immediately prior to the operation on the larynx. If the tracheotomy is performed some days in advance of the laryngeal operation, the mucous membrane has had time to adjust itself to the altered conditions under

which it receives the air, there is less coughing, and, in addition, the patient is able to swallow better and earlier following the operation. On the other hand, if the patient is phlegmatic, indisposed to brook the delay, or in fairly good condition, the tracheotomy can be performed at the time of the operation as well as it is in the Glück method of complete removal. It is doubtful indeed if the infliction of the two operations at once is much if any greater than that of a tracheotomy alone.

The location of the tracheotomy should be low, but it will depend on the length of the neck, the depth of the soft tissues, and the location of the isthmus of the thyroid. One skin incision, as a rule, is sufficient for both operations, but it is conceivable that in a very long slender neck there might be two, one for a low tracheotomy and one for the operation proper. In all my cases the incision for the operation served also for the tracheotomy.

One should be prepared with tracheal tubes of different sizes and lengths. One of these should be long and flexible, and the Hahn or sponge-covered tube and the Trendelenburg tampon cannula should both be at hand, although neither may be necessary.

Some do not perform tracheotomy but keep a cannula through the cricothyroid ligament for some days after operation.

The next step is to split the thyroid cartilage in the angle between its two laminæ, *i.e.,* in or near the median line, so as to protect the anterior insertions of the vocal folds, and this is by no means as easy as it would appear. This cartilage with the cricoid begins to ossify soon after the twentieth year, and in elderly people, the age at which cancers occur, it is often completely turned into bone, requiring a very strong sharp instrument to sever it. Scissors are recommended by most surgeons, but, as a rule, will be found totally inadequate, and very strong bone cutting shears or forceps will be necessary. The difficulty in the way of using any strong instrument is in introducing a blade, which must be large in order to be effective, through the cricothyroid membrane, without pushing off the lining mucosa and thus detaching the anterior end of the sound vocal cords even if the cord is spared at the time of operation, its attachment may be endangered through subsequent necrosis. In one case reported herewith, this accident happened—the anterior end of the opposite cord was stripped to some extent, was replaced by a stitch, and for a long time afterward showed in the laryngeal mirror as a beginning invasion. The laryngologist who had the case under observation suspected it of being a recurrence until this circumstance was recalled, and this, coupled with the fact that there

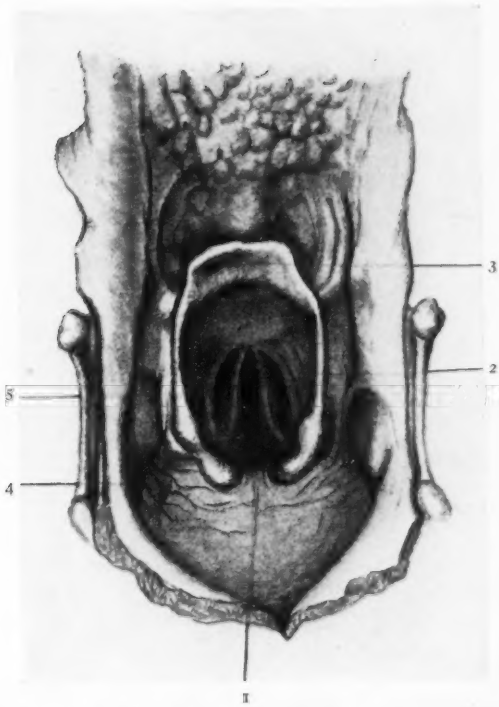


FIG. 1.—Extrinsic cancer is located at 1, interarytenoid space; 2, aryteno-epiglottic folds; 3, epiglottis; 4, pyriform fossæ. Intrinsic cancer is located at 5, vocal fold is somewhere below that level. (After Cunningham.)

FIG. 2.—Showing network of lymphatics in interior of larynx (see text). (After Most.)

FIG. 3.--Showing exit of lymph-vessels from larynx and the nodes into which they empty. (Adapted from Keen's Surgery, after Most.)

FIG. 4.

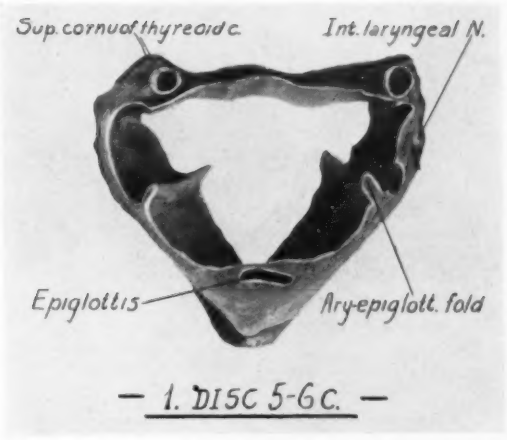


FIG. 5.

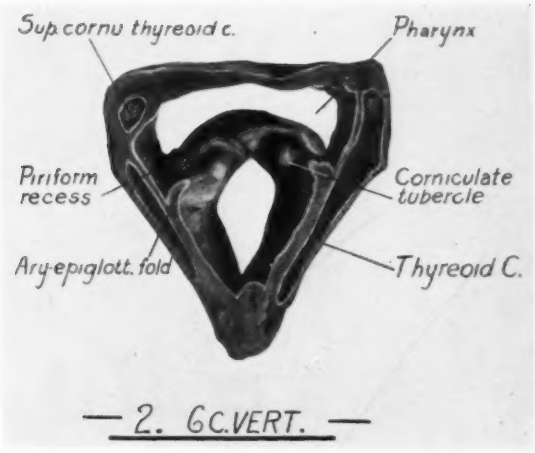
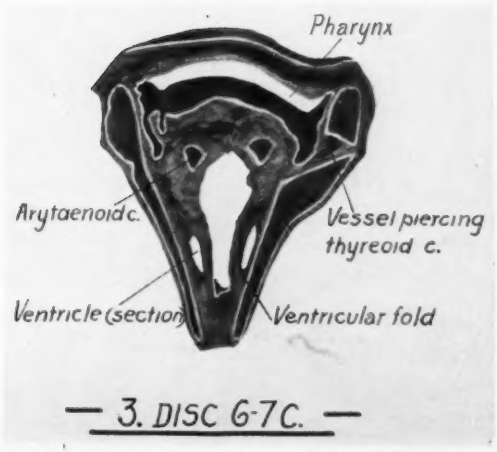


FIG. 6.



FIGS. 4–9.—(Original.) Transverse sections of larynx at different levels. They indicate the depths to which dissections can be carried in dissecting away the vocal cord. Figs. 6, 7 and 8 are particularly useful, indicating where the periosteal elevator and where curved scissors will best serve the operator. For further description see text.

FIG. 7.

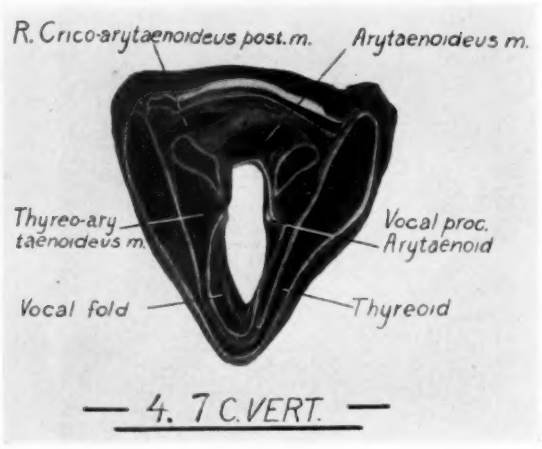


FIG. 8

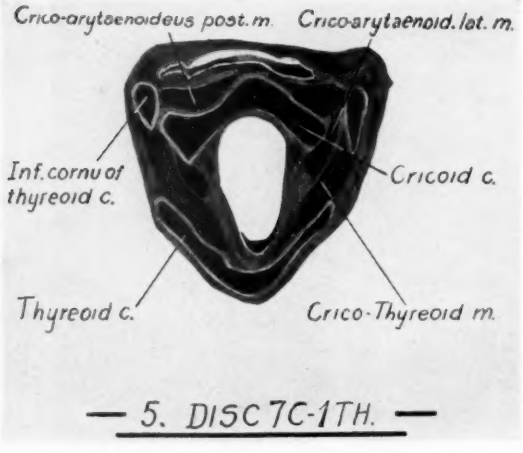
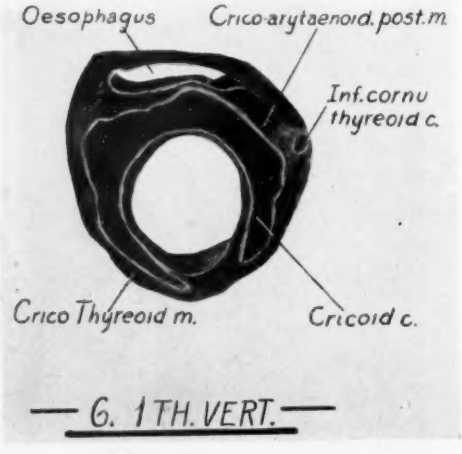


FIG. 9.



was no increase in size, led to the correct conclusion that it was not an extension of the growth.

As one splits upward there is danger of wounding the epiglottis, and, remembering the earlier teaching that the epiglottis closes down over the upper aperture of the larynx during deglutition, it was disturbing to find, in one case, a large rent in the central tendon of this structure. Later teachings, however, are to the effect that the epiglottis is not of great importance in the act of deglutition and can be removed without interfering, in any great degree at least, with the passage of food.

The thyroid having been opened (partial laryngofissure), it is now necessary to tampon the larynx above the cannula and also the pharynx to prevent soiling from the mouth or the œsophagus. Prior to this, it is necessary, if general anæsthesia has been used, to swab the larynx carefully with cocaine-adrenalin solution, as already indicated. If a pack is carried into the œsophagus, it not only prevents soiling but helps to locate the septum between larynx and pharynx.

Sometimes the room acquired by opening and spreading the thyroid is insufficient. It will depend on the angle at which the two laminæ of the thyroid meet. In the adult male this angle is about ninety degrees; in the female, about one hundred and twenty degrees, which means that in the latter it will be more difficult to expose the side walls. If insufficient, it may be necessary to cut the cricoid anterior arch (thyreocricotomy or total laryngofissure) and, although it is best not to do this, no great harm follows the manœuvre.

After the interior of the larynx has been thus exposed so that the growth can be seen in all directions, it should be completely outlined by a knife, cutting down to the cartilage about one centimetre beyond the edge of the growth, then the diseased tissues should be taken away with a sharp periosteal elevator and short strong scissors markedly curved on the flat.

To determine how deeply one should go I have had some frozen transverse sections made (Figs. 4, 5, 6, 7, 8 and 9). By reference to these, it will be seen that at the front and sides the tissues can be peeled cleanly from the inner surface of the thyroid cartilage, in the lower posterior part from the inner surface of the cricoid ring, that is, the dissection should be subchondral. Higher, at the level of the arytenoids, it is necessary to exercise care. If the growth is limited to the centre of the cord, it will only be necessary to cut the posterior end away from the vocal process of the arytenoid. If it extends further back, involving the vocal process, a part or whole of the arytenoid on that side should be

taken away. When the arytenoid is involved, or when the growth crosses the posterior commissure involving the interarytenoid space, the case is not suitable for removal by thyrotomy, but a partial or complete laryngectomy should be performed, a condition for which one should always be prepared beforehand. The lateral muscles which rest under the thyroid on the conus elasticus, particularly the thyro-arytenoid and the conus elasticus itself, will be sacrificed in this dissection.

Control of the hemorrhage, as a rule, is not difficult, and bleeding is usually very much restricted through the use of cocaine and adrenalin. Vessels should be tied or crushed, and sometimes, when a vessel perforates the cartilage, it is difficult to do either, and then it may be necessary to use the cautery, which can be utilized only when local anæsthesia or chloroform has been employed. If absolutely necessary, one may control the bleeding by tamponing the cavity of the larynx, but most authors advise against this, regarding prompt closing as an important part of the operation.

Closing is effected by two or three stitches in the perichondrium and soft tissues, or, if the cartilage is not ossified, the sutures may be made to pass through the cut edges. In ossified cartilage, there is no need to take this precaution. Drainage need not be employed, as a rule, for the wound is very superficial. An attempt to close the defect in the mucous membrane as far as possible is recommended by some.

The after-treatment is to keep the patient with head low until after consciousness has returned, then in the semi-upright posture in a room in which there is plenty of moisture in the air. The tube can be removed in twenty-four or forty-eight hours, if no œdema obstructing the pharynx is present, which may be determined by laryngeal examination, or by taking the tube out and testing it, standing ready to replace it at a moment's notice. The patient should be gotten up promptly, as a rule on the second or third day. Feeding is a difficult problem, because the wounded larynx does not draw up well under the backward protruding tongue during efforts of deglutition. One of my cases, the younger, who was more agile, was able, by putting his head lower than the rest of his body, to drink milk much as it is taken by a dog or cat, when, to do so in the ordinary posture, caused distressing strangulation. It is possible that a preliminary tracheotomy might permit the patient to take food earlier for the same reason that respiration is more easily carried on. When normal acts of swallowing cannot be performed, it may be necessary to feed through the nasal tube.

Necrosis of the edge of the cut cartilage often follows the laceration of tissues, as they are very poorly nourished. One of my cases kept

on for several months discharging through a small sinus, doing the patient more mental than physical harm. On any account, however, the sooner such a process is over, the better.

The functional results are excellent: The cases I have done talk very well. As to recurrence, in two of them the prognosis is certainly favorable, one having already gone over three years, another nearly that length of time. In addition, I have two other cases, five in all, operated on long ago from which I heard some years later but have recently had no communication.

Conclusion.—Laryngofissure is applicable to over one-third of all cases of laryngeal cancer. It is exclusively adapted to endolaryngeal cancer in its incipient stages. A circumscribed movable tumor near the centre of one vocal cord represents the most favorable case for laryngofissure. The operation is sometimes extended to cancer still movable but which has attacked the anterior commissure, the ventricle or the subglottic space. Laryngofissure is absolutely contra-indicated in all cases in which the arytenoid cartilage and the interarytenoid fold are involved, also in other extrinsic cancer. It is not often enough performed and is sometimes attempted too late. Its extent should be absolutely determined beforehand, otherwise one should be prepared for a semi or complete laryngectomy. The mortality is small—0.2 per cent. Speech is always possible, often satisfactory.

CASE I.—W. R. M., insurance broker, aged sixty-four years. Patient always has had a sensitive throat and has had almost constant treatment. Because of increasing hoarseness, he consulted Dr. Stewart, who referred him to Dr. Chisholm in October, 1911. In December, 1911, two specimens were removed by Dr. Coakley for examination. Second specimen was suggestive of malignancy.

Operation (January 27, 1912).—The patient had a short neck. The incision was made from the hyoid bone to episternal notch. The isthmus of the thyroid was in the way and was severed between ligatures. A tracheotomy tube was inserted. The thyroid cartilage was split in the median line and the cricoid also to increase exposure. The left vocal cord was trimmed out entirely and its base cauterized. The anterior end of the right cord was also taken away. The mucous membrane in the vicinity of the anterior commissure was also removed.

Pathological Report.—Specimen consists of a greatly thickened vocal cord and a small portion of tissue removed from the wall of the larynx.

The vocal cord presents near its centre an irregularly outlined indurated elevation, the surface of which presents several small crypts.

Microscopical examination of sections made directly through this area reveals the histology of an epithelioma.

Microscopical examination of the small particle of tissue removed from the wall of the larynx fails to reveal evidence of secondary deposits.

Present condition: patient talks fairly and feels better than for a long time. He states that a feeling of stiffness in the throat which has existed for a long time prior to operation has disappeared.

CASE II.—I. J., physician, aged fifty-two years.

Family History.—Striking history of malignancy on paternal side; father, one uncle, two aunts, and a cousin having had cancer. A maternal aunt also suffered from the same disease.

Hoarseness began in 1907–1908. This consisted of a slight huskiness which increased gradually until 1910, when he had almost complete loss of voice. He received no treatment until 1910. Patient then went to a specialist who made a diagnosis of laryngitis with some œdema of vocal cords. He took treatments occasionally until November 1, 1912, when he consulted Dr. E. H. Griffin, who made a diagnosis of epithelioma. Was also seen by Drs. Chisholm, Coakley and Bosworth, who confirmed the above diagnosis. Dr. Coakley removed a specimen which disclosed malignancy. While the diagnosis was being determined, potassium iodide was given in forty-grain doses three times a day for four weeks, in spite of a negative Wassermann reaction. No improvement followed.

Operation (December 31, 1912, by Dr. Stewart).—Tracheotomy under local anæsthesia followed by general anæsthesia through tube, and right vocal cord with tumor removed. The patient had difficulty in swallowing fluids for some time and was compelled to drink with neck lower than chest. Tracheotomy tube was removed at end of fourth week.

About March 15, 1913, he began to have difficulty in breathing again and returned to New York. Because of increasing difficulty in breathing, a tracheotomy tube was inserted about April 15, 1913. Examination of larynx disclosed almost complete stenosis. Examination of specimen removed through tracheotomy tube showed the histology of granulation tissue.

In July, 1913, because of the stenosis, the larynx having filled with either granulation tissue or new growth, the patient was referred to Dr. Howard Kelly of Baltimore, who gave two intralaryngeal and two extralaryngeal treatments with radium from July 18 to 27, 1913. After the first treatment there was a profuse discharge from throat, and on July 27 he was able to get air through larynx. On July 28, respiration through larynx was

fairly free and he has been breathing through larynx ever since. He has taken radium treatments on the following dates: September 18 and 19, 1913, intralaryngeal treatment for two hours and extralaryngeal treatment with six hundred and fifty milligrammes for fourteen hours, the last treatment being January 11, 1914, with eight hundred and two milligrammes.

Though he wears a tracheotomy tube, it has been plugged since the fall of 1913. Patient has seen Dr. Kelly twice since, but has received no further treatment.

Present condition: Voice hoarse, breathing free.

CASE III.—R. K., aged seventy years, married, German broker.

Family History.—Negative.

Past Personal History.—Patient has been a singer during entire life. Exercised voice daily. For many years was broker on floor of Stock Exchange, where voice was subjected to prolonged strains. Has smoked 2 or 3 cigars daily.

In 1908 he noticed a roughness in voice when delivering a short address. On one occasion during the same year after singing a difficult work, he experienced a sharp, knife-like pain in the larynx. Because of increasing roughness in voice, he consulted a throat specialist, who treated him for about a year and, in May, 1910, removed from the right vocal cord a papilloma. Following this he resumed his singing with no discomfort and greater success. After six months he became aware that his throat was not normal and gave up singing. The roughness in the voice reappeared and a specimen removed about November 1, 1914, proved to be malignant. He suffered no pain, no bleeding, no coughing, no difficulty in breathing. His only symptom was hoarseness.

Operation (November 11, 1914).—Tracheotomy under chloroform preceded by morphine. Anæsthesia continued through tracheotomy tube. Thyroid opened. Mass very distinct, involving and below true vocal cord on right, slightly across anterior commissure. Portion on left removed first; then that on right was trimmed off, dissecting it with curved scissors and a small periosteal elevator. Cartilage and upper part of wound closed. Tracheotomy tube left in.

Remarks.—Anæsthesia was very satisfactory.

Pathological Report.—Specimen consists of a small piece of tissue taken from surface of larynx below vocal cords. Microscopically, sections show a typical downward growth of squamous epithelium with "pearl formation." Diagnosis: Epithelioma.

Examined by Dr. Coakley May 7, 1915, who reported no evidence of a recurrence. At present writing, exactly one year after date of operation, there is no return of growth.

SUPPURATIVE PERICARDITIS

By Goodrich B. Rhodes, M.D.
of Cincinnati, Ohio
(From the Surgical Department of the Cincinnati General Hospital)

In 1897 John B. Roberts tabulated 35 cases of purulent pericarditis in which operative interference other than paracentesis had been practised. This represented the total number of cases up to that date. In 1900 C. B. Porter collected 16 additional cases. He was followed, in 1909, by Ellsworth Eliot, Jr., who added 22 cases, bringing the total number to 73. In all of these reports the literature has been admirably collected and brought up to date, therefore this paper will concern itself principally with the cases and literature subsequent to Eliot's article. To these 73 cases it is the purpose of this article to add 13 cases, 11 collected from the literature, with 2 additional cases from the Cincinnati General Hospital.

In 1649 Riolanus advocated tapping the pericardial sac for effusion, and his therapeutic suggestion was reiterated fully one hundred years later by Senac, but unfortunately there exists no documentary proof that either of them put their conceptions into actual operative practice. Corvisart, in 1806, denounced the proposed operation, claiming it to be dangerous and unjustifiable. To Romero of Barcelona belongs the credit of first performing paracentesis. In 1819 he performed the operation three times, twice successfully. In 1854 Trousseau reported several successful cases and Clifford Allbutt introduced the operation into England in 1866.

Roberts credits Hilsmann (1844) with the first incision and drainage of the sac, but v. Walzel cites Romero as being the first to drain the sac by intercostal incision, but gives no date, and I have been unable to verify this statement. The first rib resection, combined with incision and drainage of the pericardium, was performed by Rosenstein, of Leyden, in 1881. Kocher states that resection and trephining of the sternum to afford access to the pericardium was practised by Riolanus in 1653.

The incidence of suppurative pericarditis varies somewhat with the different observers. It is comparatively rare in children, approximately two-thirds of the cases occurring in adults. The autopsy records of the Harvard Medical School from 1896–1911, as compiled by Barkan

and Lucas, show 363 cases of pericarditis in a total number of 3,248 autopsies. Of these 363 cases 6 cases of suppurative pericarditis were recorded, or 1.6 per cent. Cowan gives figures based on 324 cases of all types of pericarditis, 24 of which were suppurative, or 7.4 per cent. In infants by far the greatest number of cases occur during acute pulmonary infections, empyema or pleurisy, while in older children it occurs oftenest in the course of an acute endocarditis. Primary pericarditis in children is rare, the secondary type showing the major number of cases, of which rheumatic affections claim from 40 to 60 per cent. (MacLeod, Weill).

The bacteriology of the exudate exhibits a wide range. Staphylococci, streptococci, Fraenkel's diplococcus, B. pyocyaneus, B. tuberculosis, B. coli communis, influenza, rarely B. lactis aerogenes, and B. proteus vulgaris, and very frequently the pneumococcus have been found, while some cases report a sterile exudate. The pneumococcus is preëminently the organism responsible for the condition in infants, while in adults and older children the streptococci and staphylococci are present in the majority of cases. In the complete series of 85 cases the infecting organism is reported in but 21, the pneumococcus was found in 9 cases, staphylococci in four, streptococci in three, a mixed infection of staphylococci and streptococci in two, the colon bacillus in one, the bacillus pyocyaneus in one, and a " double coccus " in one.

The pathology and symptomatology present very interesting features. There are two distinct sinuses in the pericardial sac, one, the larger, lying to the right of the large vessels at the base of the heart, and the other, a smaller one, situated along the right posterior edge of the sac, corresponding to the sternal angle of the fifth intercostal space. In beginning exudates, these sinuses fill first, and hold roughly 200 c.c. Even this amount of fluid can push the heart forward against the sternum, as is seen in Kiliani's case. A small amount of pus in the pericardium can give no symptoms, aside from its constitutional evidences and the increased leucocyte count, and can be diagnosed with certainty only by the X-ray. This constitutes the first stage of the lesion, and one, unfortunately, very seldom diagnosed. A second stage is instituted with the increase of the exudate up to the limits of elasticity of the sac. This stage is the ordinarily observed stage of physical signs. When, however, the limit of elasticity of the sac is overstepped by the amount of exudate, a third stage is seen, to which Rehn has given the name of Herzdruck. Rose calls it Herztamponade. It is produced by the intrapericardial pressure exceeding the intra-auricular pressure. The symptoms were shown splendidly in the

subacute form before operation in my case, and after operation when interference with the return flow during irrigation caused it in an alarmingly rapid manner. This latter accident occurred also in the cases of Blake and Parker.

In the slowly developing form of Herzdruck the symptoms are very striking. The patient is cyanotic, evidently in great respiratory embarrassment, even orthopnœic in extreme cases. Pain in the left arm is a common symptom. Precordial pain, increased by expiration, with a feeling of oppression in the chest. Œdema of the upper thorax and one or both arms is often seen, aside from thrombosis. Some cases have shown, as did mine, slight rigidity and pain in the upper abdomen, usually on the left side. The veins of the neck are distended and the pulse is rapid and small. A very prominent symptom in my patient, as in the cases of v. Eiselsberg and Harrigan, in which the intrapericardial tension was high, was great irregularity of the pulse. In very few of the cases is this found, and it would seem to me to be more dependent on great distention of the sac than on inflammatory irritation of the pericardium, as has been claimed by Heitler. My reason for this view is the instantaneous return of the pulse to normal frequency on opening the pericardium in my case and the slower return in Harrigan's case after removal to the ward. Of course the mere withdrawal of fluid will not immediately relieve an inflammatory irritation, and if arrhythmia is to be explained as a result of pericardial inflammation, why do not the majority of cases of pericarditis show it?

The increase in the exudate pushes the heart forward, so that in the greater number of cases the heart is found to occupy a position directly against the anterior chest wall. Rehn, Brentano, Curschmann, and Schaposchnikoff hold that this is always the case, while Eichel contends that it is not always in contact, and even may occupy a posterior position. A study of the reported cases in which the position of the heart is mentioned shows that in four cases the heart is said to be anteriorly placed, and in two cases, those of Sibley (operated on by Mr. Lane) and Harrigan, it lay deep in the thorax, while Eichel reports that all his cases, as did mine, had fluid between the heart and anterior pericardium. However, the exceptions must not blind our eyes to the important fact that the heart is usually held anteriorly by the exudate.

Among the rarer symptoms Blechmann has called attention to the genu-pectoral position assumed by some patients. Hertz claims this to be pathognomonic, and of course due to the effort to relieve the large vessels of the backward pressure of the heart and exudate.

In the X-ray we possess a most valuable aid in diagnosis, especially

in the early cases, and in children. In adults care must be exercised to avoid error in diagnosis, for in some of the early cases the radiographs have closely simulated those of aneurism of the first portion of the aorta. Purulent mediastinitis also presents a similar picture. No obscure chest condition presenting a high leucocyte count should be allowed to escape the X-ray, for in that direction may lie our sole opportunity to make an early diagnosis, while the fluid is still in the pericardial sinuses.

The combination of these special symptoms with the well-known physical signs of fluid in the pericardium and a high leucocytosis is sufficient to make the diagnosis. The leucocyte count runs high, 20,000 to 38,000, and it is well to remember that an associated empyema or pneumonia may complicate both the leucocytosis and the physical signs. The liver is very often pushed downward, especially in large effusions, sometimes a hand's breadth below the free margin of the ribs. In one case the diagnosis of liver abscess was entertained.

Aspiration of the pericardium, for treatment or diagnosis, must be most emphatically condemned. Fevrier has collected 9 cases from the literature which were treated solely by aspiration with a mortality of 100 per cent., not a very encouraging percentage, even when compared with the high percentage following operation. I am not aware of a single case which has been cured by simple aspiration. For diagnostic purposes many important facts contra-indicate its employment. It is usually superfluous, if a careful study of the case has been made, and due attention paid to the X-ray, leucocytosis and temperature chart. It can be of positive danger, as it is impossible to be certain where the pleural reflexion lies in any given case, and there is no guarantee that the needle will not pass through normal pleura into the pus cavity, allowing the pus under tension to follow the withdrawal of the needle. The accompanying drawings, made for me under the direction of Prof. Knower of the Anatomical Department of the University, were prepared accurately from cadavers, showing the variations in the lines of reflexion of the pleura from the chest wall and its relation to the pericardium. A study of these will show how frequently the pleura will be penetrated if we introduce a needle in accordance with the usually accepted sites for aspirating the pericardium. It has been stated that in high grade effusions the parietal pleura is stripped back by the distended pericardium, making paracentesis a safe procedure. Although this may be true in some cases it most certainly does not always occur, as a large number of the reported cases will show. It has been my fortune to open the distended pericardium twice, once for hemorrhage

from stab wound, and once for pus, and in both cases the pleural reflexion had to be pushed aside to allow entrance into the pericardial sac.

Adhesions binding the heart to the anterior chest wall may render puncture of the heart unavoidable. It must not be forgotten that in the larger proportion of cases the heart is forced against the chest wall by the fluid, in a position easily reached by the needle. Paget's case died from hemorrhage from the right ventricle following paracentesis, and in Jacob's case adhesions were found post mortem. Venus has collected seven cases of puncture of the heart during aspiration, in one of which sudden death occurred.

Furthermore, there is no certainty that the needle will reveal pus, thus blinding our eyes to the true state of affairs. As we have seen the beginning exudate is found in the accessory sinuses, behind the heart, out of reach of the needle. Kiliani's case showed this beautifully. The needle may become plugged, or the exudate too viscid or thick to flow through it. A consideration of these facts should make us less ready to plunge a needle into every suspected pericardial effusion. A resection of one costal cartilage followed by pericardiotomy, or aspiration of the pericardium under direct inspection is not a serious procedure, and should be the method of choice.

The prognosis of these cases presents variations due to differing circumstances. Cases unoperated or treated by aspiration alone can be said to have no chance, while the outlook for the cases submitted to operation affords hope of recovery if operative interference is carried out early, if no complications are present, or if present are detected early and remedied. I refer especially to the development or coincidence of pleural empyema. A study of the causes of death in the fatal cases shows that in by far the greater number recovery was not to be expected while such antagonists as pyæmia, sepsis, and pneumonia are still unconquered. Of the 86 cases 45 recovered and 41 died, a percentage of 52.3 per cent. recoveries as against 47.7 per cent. deaths.

Treatment.—Since the last review of the subject Mintz' method of operative attack is the only addition to the already numerous avenues of approach to the pericardium. This method was proposed by him in 1903, but was first used on the living patient since the last review. As described by him it consists in an incision along the under border of the seventh costal cartilage. A skin and cartilage flap is now made, and opened from above downward. Access is now permissible to the extraperitoneal space in which the pericardium can be opened without danger of injury to the pleura.

All the described methods have as their object the incision and

thorough drainage of the pericardium. Certain lessons can be learned by study of the case reports. The exudate should not be allowed to escape too rapidly from the pericardium, for too rapid lowering of the intrapericardial pressure may result in sudden "still stand" of the heart, as occurred in Harrigan's case. It might even be advisable to aspirate the pericardium before incising it. If no exudate is observed anteriorly examine behind the heart, as it may be pocketed there. The sinuses must be thoroughly explored.

The question of drainage and irrigation is of the greatest importance. Free drainage must be maintained, and certain obstacles stand in our way. The continuous action of the heart tends to force out the softer drainage materials, such as rubber tissue, while the experience of Tartarinow (quoted by Kolb) shows the danger of the rubber tube, which caused necrosis of the heart wall by pressure. V. Eiselsberg advocates stitching the pericardial sac to the muscle layer, while Gussenbauer sews it to the skin margin. This when possible should be done, as the incision tends to close very rapidly, but where there is extensive œdema of the soft tissues, whether from anterior mediastinitis or from Herzdruck, as in Eliot's case, and in my own, it is impossible. Drainage of some description must be used, as a considerable portion of the fatal cases show no provision was made for permanent drainage. Fear of necrosis in my case led me to discard the rubber tube in favor of rubber tissue, which was passed at each dressing into both sinuses of the sac with dressing forceps after irrigating the sac with salt solution. This method of drainage proved amply sufficient, as the post-mortem showed, although the daily irrigation and replacing of the drains was very painful.

I am indebted to Dr. C. E. Caldwell, of the South Surgical Division of the Cincinnati General Hospital, for the privilege of operating on this case. My thanks are also due to Dr. Ransohoff for the permission to report his case from his service in the General Hospital, and to Prof. Knower for his assistance in the anatomical work.

AUTHOR'S CASE.—C. C., German cook, aged twenty-six years, was admitted to the Cincinnati General Hospital on the medical service of Drs. Greiwe and Fihe, July 25, 1914, complaining of pain in the side on deep inspiration. This began suddenly July 12, after sleeping with no covering. He woke up suddenly and could not get his breath. Headache.

Examination.—Pale, obese adult. Temperature 102.8°; pulse 116; respirations 36. Heart and lungs negative. Pharynx congested. Abdomen, no dulness, but sensitive to pressure in epigastrium. Otherwise normal. Treatment: Catharsis, rest in bed.

FIG. 1.

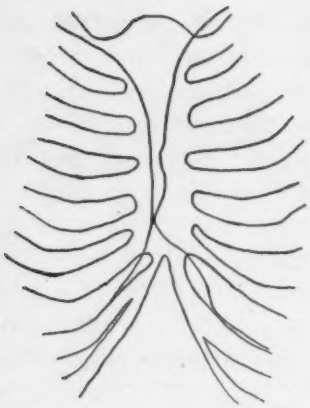


FIG. 2.

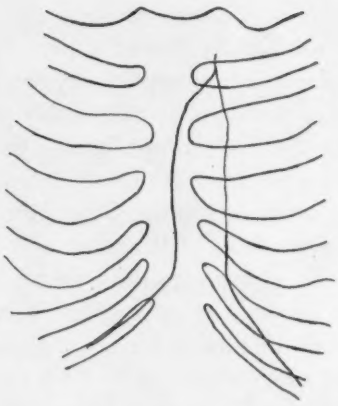


FIG. 3.

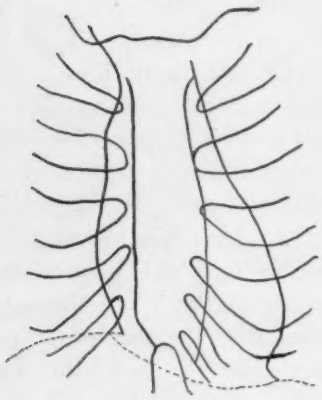


FIG. 4.

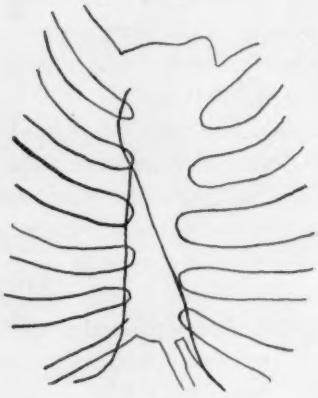


FIG. 5.

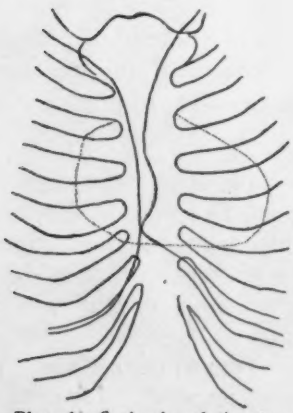
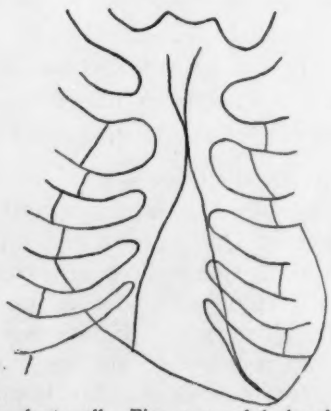


FIG. 6.



FIGS. 1–6.—Pleural reflexion in relation to anterior chest wall. Figs. 3, 5 and 6 also show heart outline.

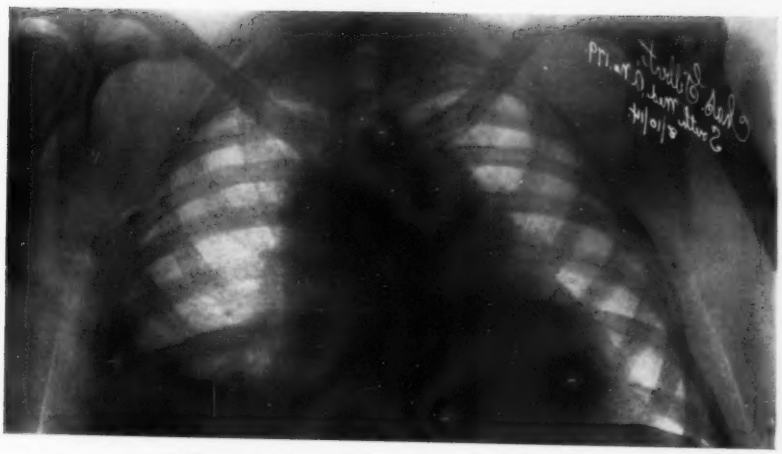


FIG. 7.—Radiogram of thorax in author's case.

July 27: Sore throat. Alkaline irrigation used.

July 28: Urine showed albumen and casts. Blood pressure 160 mm.

August 2: Marked arrhythmia of pulse. Dusky cyanosis with pain referred to upper abdomen.

August 3: Same condition, but pain now is felt under sternum. Sensation of gripping around the heart. Dyspnœa, not relieved by amyl nitrite inhalation. Leucocyte count 38,000, 84 per cent. polymorphonuclears.

August 8: Friction sound heard over pericardium. Moderate dulness in left lower axilla and back. Tenderness is greater in the epigastrium and a rounded mass the size of a baseball can be indistinctly felt. Rigidity of the right rectus overlying area of dulness on percussion. Patient seen by author, who placed the lesion in the thorax rather than in the abdomen, and advised X-ray.

August 10: Œdema of wall of right chest and arm, not of angioneurotic character. Blood-pressure 140–145 mm.

August 11: X-ray of chest shows an enlarged heart shadow (see Fig. 7). Paracentesis in fifth interspace, three fingers' breadth from sternal margin. Pus withdrawn. Aspiration of right pleura, eighth interspace, below angle of scapula gave 24 ounces of slightly turbid fluid, straw colored. Transferred to South Surgical Division.

Operation (August 11, 1914).—Dr. Rhodes. Operation started in sitting position under local anæsthesia. After skin incision ether substituted in recumbent position. Hockey-stick incision, starting from third costal at left sternal margin, downward and curving outward along the seventh rib. Great œdema of tissues. Fourth and fifth costal cartilages and portions of ribs resected subperiosteally. Anterior mediastinum greatly infiltrated with œdema. Internal mammary artery not encountered. Pleural reflexion seen about 1 cm. from left sternal border, evidently not pushed to left by exudate, and must have been perforated by the needle in aspirating. Pericardium was now opened, and a large amount of greenish-yellow pus evacuated. A sphygmomanometer had been adjusted to the arm before incising the sac and the blood-pressure registered 150 mm. The pulse was exceedingly irregular. *Immediately following the escape of about one quart of pus the pulse became regular,* while the blood-pressure more slowly sank to 125 mm. The heart was noticed to lie about 1 cm. from the pericardium in front, so that quite a definite layer of pus separated it from the pericardium. The pericardium was now irrigated with salt solution. Two large drains of rolled rubber tissue were passed into each pericardial sinus, and other

strips passed between. It was found impossible to sew the pericardium to the skin because of the thickness of the intervening tissues, due to œdema and obesity of the patient.

August 12: Patient in good condition. Wound draining well. Much more comfortable. Cyanosis and dyspnœa have disappeared. Irrigation of pericardium with bichloride, 1–3000.

August 13: Pain in left elbow. Arm swollen and painful. Thrombosis of subclavian vein suspected. Irrigation of sac.

August 14: Severe pain in abdomen and chest. Daily irrigation of pericardial sac. This was done with a catheter introduced into the pericardial sinuses. On this occasion the outlet to the irrigating fluid became clogged in some manner, while the fluid still flowed into the sac under a pressure of about 2½–3 feet elevation. The patient suddenly became cyanotic, in extreme dyspnœa, then gave one or two convulsive movements and became apparently lifeless. The catheter was rapidly pulled out, followed by a gush of irrigating fluid. Respiration began immediately and in three minutes the patient was as well as previously.

August 14–19: Condition about the same.

August 19: Signs of fluid in left chest. Patient weaker. Aspiration withdrew one litre of serosanguineous fluid. Patient delirious. Heart strong but general condition bad. Died 9.30 P.M.

Post-mortem Report.—Sex, male. Age twenty-six. Admitted July 25, 1914. Died August 19, 1914. Necropsy 15 hours after death. Staff Officers, Drs. Greiwe and Fihe. Pathologist, Dr. Woolley.

Clinical Diagnosis.—Pyopericardium; pleurisy with effusion; nephritis; myocarditis.

Anatomical Diagnosis.—Acute fibrinous purulent pericarditis; acute vegetative mitral endocarditis; acute interstitial myocarditis; septic infarcts in lungs, spleen and kidneys; acute fibrinous pleuritis and mediastinitis; acute splenitis and hepatitis; axillary and coronary venous and hepatic arterial thrombosis; fatty liver; general anæmia; Meckel's diverticulum; costotectomy.

Microscopical Diagnosis.—Acute diffuse nephritis; septic infarcts and miliary abscesses of liver; septic infarcts and miliary abscess and softening of spleen; septic thrombi of splenic vessels; congestion, infarcts and miliary abscesses of lung; suppurative pericarditis; septic thrombi subclavian artery.

Necropsy.—The body of a heavy, well-built, powerful man of medium height. The pupils were normal, the general color of the skin a pale yellow, upon which was superimposed a slight lividity, most evident about the face and neck. The left arm was œdematous to the shoulder. There was a slight evidence in the odor of the body, of beginning post-mortem decomposition. Post-mortem lividity was only slight. Rigor mortis had almost disappeared. Just to the left of the median line of the thorax and over the area of normal cardiac dulness was the wound of an operation which had

included a triangular costotectomy for the relief of a purulent pericarditis. The base of the operative area was covered with a yellowish-gray fibrinous mass. There was little evidence of reaction on the part of the tissue.

The body was opened in the usual way, and the sternum removed. The subcutaneous fat was well developed and thick. The omentum was in its normal position covering the appendix and was loaded with fat. The mesentery was likewise very adipose. The intestines and stomach were moderately distended with fat, but lay in their normal positions. The appendix was apparently normal. About two feet above the cæcum were the blunt triangular remains of the mesenteric-omphalic duct. The liver reached just below the costal margin. The mediastinal tissues were exceedingly œdematous, especially in the thymus area, at which place there seemed to be some incompletely fatty remnants of thymus. The lungs did not collapse, chiefly because of numerous pleuropericardiac adhesions.

The pleural cavities contained a slightly increased amount of a fibrin containing fluid, and the pleural surfaces chiefly over the lower lobe in the left, and the lower and middle lobes in the right, were covered with a thin layer of fibrin, beneath which the pleura was roughened and congested.

The lungs were both œdematous, especially so in the lower lobes, in which beside the increased fluid there were numerous areas of consolidation, mostly at the edges of the lobes, and mostly of a generally triangular shape. Section into these showed them to have a rather chocolate-grey color, though they were much darker than the adjacent pulmonary tissues, and paler than the red infarct, though they were moister than the white, and showed no well marked zone of demarcation. They were probably septic infarcts. Within the substance of the lungs were a number of small abscesses.

The heart was of about normal size, and was covered with a thick fibrinous exudate in the parietal pericardium. Beneath this exudate, congestion which involved the myocardium was well marked. The myocardium was pale and slightly (macroscopically) fatty. The valves with the exception of the mitral, were apparently healthy. Upon the mitral leaflets were two large (1 by 3 mm.) beefy red vegetations, together with a number of minute ones. The aorta was smooth. In the vena cava there was found a reddish mass of thrombus which projected into the lumen in form of a concave plate (1 cm. in diameter) with thin edges. This proved to be the proximal end of a thrombus which extended into the axillary vein and its branches. The left coronary vein was also thrombosed.

The liver was but little larger than normal, but was excessively pale and fatty. Upon its surface were seen a number of small dewdrop areas the size of miliary tubercles, situated just beneath the capsule and extending into the substance. A few similar areas were discovered in the parenchyma (miliary abscesses?). A number of thrombosed vessels apparently belonging to the hepatic system were discovered. The biliary vessels were patent. The gall-bladder was slightly congested, but otherwise healthy.

The pancreas was congested, but no other abnormality was noticed.

The stomach and intestines showed nothing remarkable when they were opened.

The spleen was enlarged, fairly firm, and with rounded edges and

smooth capsule. At the lower pole was a pale area, somewhat swollen, and surrounded by a zone of extreme congestion. Near it was a similar, though darker area. Both were triangular. On section the former proved to have all the characteristics of a white infarct, while the latter was similar in appearance to the pulmonary infarcts already described. There were also, in the spleen, scattered groups of pale almost miliary areas which were probably small abscesses.

The kidneys were larger, pale and juicy. The cortices were widened and both organs showed all the characteristics of an acute diffuse nephritis. The glomeruli were congested, the cut edges of the organs curled outward and the capsules were readily stripped. In the cortices and medullæ, chiefly in the former, were numerous small areas of suppuration surrounded by zones of congestion. Some of these were spherical, others were linear. In some instances such lines extended entirely across the cortex. The pelves, ureters and bladder showed nothing abnormal.

DR. RANSOHOFF'S CASE.—J. P., 28 years old, single, colored laborer, was admitted to the Cincinnati General Hospital, January 10, 1913, complaining of pain on the right side, shortness of breath and cough. He was placed on the medical service of Dr. Mark A. Brown.

He had had measles ten years ago, chicken-pox and mumps when a child. Rheumatism in 1905, confined to bed for two weeks. Gonorrhœa at age of 22, syphilis at 23.

About January 7, 1913, when working, he developed pain in right side, shortness of breath, cough with tenacious sputum and came to hospital for treatment.

Examination.—Well-developed negro. Temperature 102.4°; pulse 104; respiration 24. Lips dry, tongue coated, teeth in bad condition. Slight glandular enlargement in neck. Chest normally developed, expansion limited on right side, apices dull. Right lower lobe dull. Crepitant and bronchial breathing. Heart normal in outline and sound. Abdomen rigid. Liver and spleen not palpable. Extremities normal except clubbing of fingers. Urine normal.

January 14: Patient complains of pain in right side, also pain in precordial region. Pericardial friction rub heard. Morphine gr. ¼, ice-bag to precordium.

January 15: Pain easier. Rub still distinct.

January 16: Rub can be heard at base only.

January 31: Needle was put into chest, sixth interspace just beyond apex of heart and a quart of pus drawn off.

February 5: Respiration increased in frequency, 32 per minute. Above clavicle on left side a bulging is noticed, also a bulging on expiration in the second and third interspaces on left side. At the end of inspiration the heart action can be seen to the right

of the sternum. Very little expansion noticed of chest on left side below. Dilated veins seen on left side of chest.

Palpation.—Tactile and vocal fremitus present over entire right side anteriorly. It is absent over lower posterior part. It is present over upper part of left side.

Percussion.—Low pitched hyperresonance is heard over the right apex posteriorly. High pitched resonance is heard over the left apex posteriorly. Beginning at the spine of scapula on the left side going downward there is diminished resonance, soon becoming flat. On the right side just above liver a small area of dulness is noted.

A small area to the left and below the left nipple is hyperresonant. Resonance is increased over right apex anteriorly, at the right side beginning at the second rib and going downward there is absence of resonance.

Auscultation.—Diminished and absent breath sounds over the entire left side, except in small area below and posterior to nipple. Over right side there are roughened breath sounds at upper lobe anteriorly and posteriorly, and diminished breath sounds lower down.

Aspirating needle introduced into fifth interspace in mid-axillary line on the left side. Two ounces of pus withdrawn. The aspirating needle introduced into fifth interspace 3 to right of sternal border withdrew ½ ounce.

Marked œdema of left arm. Radial pulse of left side could not be felt. Left fingers cold. Pus sent to laboratory. Report by Dr. W. B. Wherry: Diplococci of staphyloccus form present. No signs of B. bulgaricus. Patient referred immediately to West Surgical Service, Dr. Ransohoff.

Operation.—Dr. Joseph Ransohoff. One per cent. cocaine local anæsthesia. Incision 6–7 inches long, parallel to left border of sternum and costal margin of left ribs (Kocher) ending internal to nipple. Periosteum of sixth rib injected with cocaine, stripped off, and 2 inches of rib resected, starting from ½ inch from sternum. Pericardium punctured and pus drawn off. Pericardium picked up with hæmostats and opened by a vertical incision, liberating about 3 pints of a fairly thick yellowish pus. Pericardium stitched to anterior chest wall and gutta percha drain inserted. Skin closed with silkworm-gut.

Patient complained of a very little pain during operation. Was given drink of whiskey while on table. Returned to ward, pulse much stronger and better than before operation. Immediately after operation the excessive dyspnœa disappeared, the radial pulse appeared, and the area of flatness on the chest became smaller.

February 6: Dressings saturated with pus.

February 7: Dressings again saturated. Removed drain and inserted rubber tube.

February 8: Irrigated pericardial sac, washing out a quantity of fibrous material.

February 12: Discharge still profuse but more viscid. Sputum examination shows no tubercular blood-cells.

February 27: Washed out pericardium and injected liquid lacto bacilline Metchnikoff.

February 28: Washed out pericardium and injected liquid lacto bacilline Metchnikoff daily.

March 1: Discharge seems to be liquefying. Amount is about same. Smears of pus of February 17 show comparatively few bacteria left and they are all inside of polymorpholeucocytes. Blood culture showed pure culture of staphylococcus albus.

March 5: Patient died.

Postmortem: Anatomical Diagnosis.—Purulent pericarditis; empyema (left pleural cavity); infarct of lung; fatty cirrhosis of liver; infarct of left kidney; thrombosis of left renal artery; congestion of lungs and kidneys; thrombosis of right internal jugular vein.

Chest.—Right lung showed congestion and an infarct in lower portion of middle lobe; pleura normal. Left pleural cavity contained about a quart of greenish pus, and the lung was found compressed into upper part of pleural cavity. It showed infarction and congestion.

Heart.—Pericardial sac was entirely obliterated except posteriorly, below and anteriorly where drainage had been established.

Abdomen.—Pancreas, spleen and alimentary canal normal.

Kidneys.—Left kidney showed a total infarction due to thrombosis of renal artery. Right kidney was congested.

CASES COLLECTED FROM THE LITERATURE

CASE I.—HARRIGAN: Weak, anæmic child, eleven years old. Trouble began one week ago with swelling in left thigh; no chill; slight elevation of evening temperature. Admitted September 10, 1912; pulse rapid, weak and irregular; heart sounds weak and distant. Temperature 100.4°; pulse 126; respirations 24. Liver, spleen and kidneys not palpable, abdomen moderately distended. Dulness, bronchial breathing, increased fremitus and moist râles over left apex. Dulness, increased fremitus, diminished voice and breath sounds over base of left lung.

Left thigh swollen, red, tender, and deep fluctuation is present.

Left pleura tapped: 6 oz. turbid fluid, containing pus cells and few Gram-negative staphylococci.

September 11: Heart action much embarrassed. Pericardium tapped: 30 minims turbid serum. No tubercular blood-cells. Cytological count, polymorphnuclears 49 per cent., large lymphocytes 33 per cent., small lymphocytes 78 per cent. Culture plates were contaminated.

September 12: Area of cardiac dulness 11 cm. to left of mid-sternal line, and increased to right of sternum. Sounds muffled but regular.

September 13: Subperiosteal abscess of left femur incised and drained. Ether anæsthesia. Cardiac and pleural condition became progressively worse for next few days. Left pleura aspirated September 26: 12 oz. blood-stained fluid.

September 28: Aspiration of pericardium through left fifth interspace, 1½ inches from sternal border. Pus withdrawn and was ejected from pericardium with considerable pressure after trocar was withdrawn.

Operation (Dr. Harrigan).—Dorsal position. Incision 4 inches long, beginning at left sternal border, passing obliquely downward and outward, crossing left costal cartilage at its centre, 1½ inches of left fifth rib and costal cartilage removed. Left pleura accidentally opened when anterior mediastinum was opened. Plugged with gauze.

Pericardium about 2 inches from surface of chest and covered with semi-gelatinous material. Pericardium incised 2 inches. Large quantity of pus gushed out forcibly, spurting two feet high. Culture showed staphylococci. Heart was deeply placed, and was motionless. No pulse was felt. Could not determine whether heart was in systole or diastole. Function resumed when gauze drain was forced into pericardium. Duration of cessation of pulsation not timed. Pulse rapid and strong. Patient was removed from hospital by parents next day, and died four days later. No postmortem.

Case II.—v. Eiselsberg (reported by v. Walzel): Nine-year-old school boy. Diphtheria and measles when five or six years old. March 1, 1903, chill and fever, and evening temperature 38.5°. Left-sided pneumonia diagnosed. Four days later extreme dyspnœa, cyanosis, and feeling of oppression. Pulse small and irregular. Ninth day a triangular area of dulness was found, to the right one finger's breadth beyond the right sternal border and to the left two fingers' breadth beyond the nipple line. Intercostal spaces to left bulged, and heart sounds could not be heard. The superficial veins in the upper half of the thorax were widely dilated. Diagnosis (Prof. Fruhwald): Exudative pericarditis. Patient became rapidly worse, and was pronounced moribund by a noted surgeon.

Operation (March 10, 1903).—Prof. v. Eiselsberg. Local anæsthesia. Incision over sternal end of fifth rib. Resection of fifth costal cartilage. Test aspiration of the pericardium showed pus. Cross incision of pericardium released about 1 litre of pus. Rubber tube drainage (2 tubes). Strophanthus by mouth. Three hours after operation pulse was easily felt, breathing full, color good, and mucosæ red. Streptococci found in pus. Condition rapidly improved, but pulse was still irregular after 12 days and temperature ran between 37.8° and 39.5°. Fistula remained open for 9 weeks, and while it was still open patient had scarlet fever. No bad results.

Nine years after, heart found in normal limits, tone full and pure. Pulse regular. Venectasia of right upper arm and shoulder. For one year after operation the veins remained as thick as a finger.

Case III.—Imerwol (V.): Boy ten years old. Five years ago took cold and had pain in right side, but recovered perfectly. Well since. Twelve days ago he fell on a bench, and struck the left anterior part of his chest violently. Two days later he appeared to have taken cold, and next day felt badly and went to bed with pain in the left side. Fever.

Examination.—Fever, cough, dyspnœa. Temperature 39°; pulse 130, regular

and full; respirations 36, rather diaphragmatic, and left side of thorax remaining immobile in respiration. Dulness on left from clavicle, embracing below the precordial area, and extending one finger's breadth beyond right sternal line. On the left the dulness continues to axillary line. Signs of fluid in left pleura. Broncho-pneumonia and congestion.

Diagnosis.—Pleuropericarditis. Aspiration in seventh space, axillary line. No result. Condition gradually worse, with abdominal and precordial pain, loss of sleep from pain and cough. Streptococci in expectoration. Nine days after entrance into hospital an aspirator introduced into fifth left intercostal space in mammary line drew pus. Operation immediately, November 20, 1905. Incision 4 cm. long in fifth intercostal space, commencing 1 cm. from sternal margin (left), toward the left axillary line. Down to pericardium. Aspirated 250 grammes of pus. Incision and drainage (tube), introduced about 10 cm. Streptococci in pus. Cultures showed white colonies, Gram-positive. Rapid fall in temperature.

Patient had a stormy time with the broncho-pneumonia, but left the hospital with normal heart outlines and good action. No retraction of intercostal spaces.

Case IV.—Imerwol (V.): Boy, nine years old, entered hospital April 20, 1908. History negative until two years ago when he had "fever." Two weeks ago had chills and fever, pain in left side. Fever became high.

Examination.—Patient looks sick. Dyspnœa. Temperature 38.4°; pulse 120; respirations 32, diaphragmatic. Precordial part of left thorax is distended. Complete dulness from left clavicle to base of thorax, and to the left to the axillary line. Precordial dulness goes to right border of sternum. Heart sounds regular, but feeble. Spleen enlarged. Diagnosis: Exudative pericarditis and pleurisy.

May 5: Aspiration in axillary region, fifth interspace, gave pus from left pleura.

May 6: Aspiration in anterior axillary line, fifth interspace (left), 300 grammes seropurulent fluid. Aspiration of pericardium, fifth left interspace, 3½ cm. from left sternal border gave pus. Improvement.

May 19: Pleurotomy in left fifth space, axillary line. 350 grammes of pus, drainage tube.

May 20: Discovered that the pericardium opens into the left pleura by an orifice. Heart sounds audible and apex beat visible. For the next four days this orifice increased in size. Case gradually improved and discharge lessened. Drains removed July 15, and gauze substituted. Wound cicatrized.

July 20: No retraction of intercostal spaces. Normal. Pus showed pneumococci.

Case V.—Tallquist: Housemaid, forty years old. Croupous pneumonia, empyema and purulent pericarditis.

March 23, 1911: Thoracotomy for empyema.

March 29: Pericardiotomy, Ollier's method. Fifth rib resected. Pericardium opened. 400–450 c.c. pus with fibrino-purulent exudate evacuated. Medium-sized drainage tube introduced and held by suture. After operation patient was in collapse, and cyanotic. Stimulated with camphor and caffeine. Temperature gradually declined from 38.5° to normal, and pulse from 120 to normal.

May 15: Patient's sputum showed no tubercular blood-cells. General condition good.

CASE VI.—v. WISTINGHAUSEN (reported by v. Dehn): Complication of pneumonia. Dulness was demonstrable over cardiac and mediastinal areas. An early radiograph showed the normally clear interspace between heart and hilus shadows was lacking. The next picture after two weeks showed a more diffuse shadow. Puncture over this dark area (area of greatest dulness) gave pus, which was removed by rib and cartilage resection. Death occurred several days after operation, under symptoms of *Herztamponade*. Autopsy showed purulent mediastinitis and purulent pericarditis.

CASE VII.—PIRADOFF: Armenian, twenty-six years old. Came to hospital with incised wound over fifth and sixth ribs, parallel to sternum, 3 cm. long, on the left side. Was sutured by resident surgeon, and advised to stay, but refused. Three days later he returned, with a temperature of 40° and shortness of breath, feeling of weight in precordium, pulse small and frequent. The site of the wound suggested precardial trouble. Examination showed heart fulness increased to the right, left and downward.

Exploratory Incision.—Superficial structures divided, exposing the fifth rib, which was found to be broken. Fifth and sixth ribs resected, and pericardium exposed, showing a small wound. Pericardium was opened. Internal mammary artery ligated. Blood-stained, foul-smelling fluid evacuated in large quantity. Iodoform gauze drain. Immediately after operation the respiration became better, and the pulse returned to normal frequency. For several days he had an afternoon temperature, but on the fourth day it fell, and since has remained normal. Now has no dyspnœa, his pulse is good, full and regular, and the heart outlines have returned to normal. Wound healed.

CASE VIII.—MINTZ (W. M.): Male, twelve years old, developed pericarditis after a double pneumonia. Was sick about two weeks. His general condition was bad; vomiting. Area of cardiac dulness extended two fingers' breadth beyond right border of sternum, and on the left to the midaxillary line.

Operation.—Mintz method, as outlined by him in 1903, and now used for the first time on the living patient. Incision along the under border of the seventh costal cartilage. A skin and cartilage flap is now made and opened from above downward, and access made to extraperitoneal space in which the pericardium can be opened without danger of wounding the pleura. After opening the pericardium 100 c.c. of seropurulent fluid escaped, and a gauze drain was inserted. Next day the normal area of cardiac dulness returned. Patient's condition improved from then on, he had normal outlines at the end of 2 months, and no pain, but still had a small fistula. Dismissed.

CASE IX.—KILIANI (discussion of Ellsworth Eliot's paper): Male, believed to be moribund. Rheumatic arthritis and peri-endocarditis. Leucocyte count 22,000. Immediate operation. Under cocaine the fourth rib and cartilage were resected and the pericardium incised. No pus found, due to the fact that it was pocketed back of the heart. After some manipulation a few ounces of seropurulent fluid were evacuated and the man made a practically uneventful recovery. Well seven years later.

CASE X.—BLAKE, J. A. (Discussion of Ellsworth Eliot's paper): On one occasion he opened the pericardium in axillary line, so much escaped that it covered the entire patient and table. The case was interesting on account of the large amount of pus contained in the pericardial sac. Great pain on introducing the drainage tube, and on one occasion irrigation caused collapse. A few days

after operation there were signs of pus further back, and an incision there revealed an empyema. In this case the pericarditis was secondary to a double pneumonia, and probably to an empyema. The patient finally died.

CASE XI.—WILLE (H.): Boy, four years old. Admitted October 25, 1911. Discharged December 6, 1911. September, 1911, contracted tonsillitis, with high fever, pains in abdomen, and was confined to bed. No cough, but breathing was irregular. Transferred to hospital.

Examination.—Lies on left side, with legs drawn up, groans continually. Appearance is pitiable. Temperature 40°; pulse 146; respirations 50, short and labored; labial herpes; nothing abnormal in heart, lungs or abdomen; urine normal.

October 5: Temperature had fallen to 37.6°–39.5°; respirations 54. Patient very pale and drowsy; lips dry. Left lower thorax showed a small swelling downward. Dulness on the left side from the second to the fourth ribs toward the axilla. Hyperresonance over right chest. Liver dulness began at fifth rib. Heart sounds weak, but clear and audible. In left axilla friction rubs could be heard, especially during expiration. Upper abdomen showed a swelling, but was tympanitic everywhere. Spleen and liver dulness normal.

October 6: X-ray showed a well-defined shadow, starting at the secnod rib and extending to diaphragm, occupying most of the thorax. No pulsation of the shadow. Aspiration in fifth intercostal space one finger's breadth to outer side of mammary line gave greyish, thick, fibrinous pus. Improvement.

October 17: Again aspirated, in same place; 100 grammes of pus drawn off. Culture showed streptococci.

October 25: Pericardiotomy. Incision with base along the left side, including fifth and sixth ribs, which were subperiosteally resected. Pleural reflexion showed about ½ cm. from the margin of the sternum. It was pushed aside and pericardium punctured, and then incised. Two hundred grammes of non-odorous pus liberated. Heart worked fast. It was not situated against the anterior pericardium, but about 1 cm. from it. Two medium thick drains were introduced back of heart. Dressing. Patient's pulse flew to 140, cyanosis, pulse hardly perceptible at wrist. Stimulation.

November 11: Temperature falling rapidly. Pulse 96–100. General condition steadily improving. Drainage now almost ceased (sixteenth day).

December 6: Wound healed. Heart sounds clear, pulse regular and normal. X-ray shows nothing abnormal. Discharged.

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THE ABDOMINAL SKIN-FLAP IN RADICAL AMPUTATION OF THE BREAST

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Various plastic operations have been recommended for covering in the defect remaining after a radical amputation of breast with extensive skin removal. In a number of patients skin grafting is necessary.

The surgeon should never be influenced in the amount of skin he will sacrifice by considerations relating to the later closure of the wound. By extensive undermining of the skin it is often possible to close a wound whose edges it had seemed impossible to approximate. The same can be accomplished by plastic operations using flaps of neighboring skin.

During the past two years I have operated upon several patients with malignant disease of the breast, who had metastases in the skin of the chest wall below the breast, so that the radical removal of the disease required a widespread excision of skin and subcutaneous tissue. The large defect that remained could not have been closed by any of the plastic methods ordinarily used and skin grafting would have been necessary. By means of a large flap of skin from the abdominal wall the raw surface was easily covered over. The steps of the procedure are shown in Figs. 1–4 and can be understood without further explanation.

The skin of the abdominal wall is generally very lax and receives abundant blood supply from branches of the arteries which run through the wall of the abdomen from behind forward. If the base of the skin flap is not too small the tissues will be well nourished with blood, and there is no danger of sloughing or of marginal skin necrosis. After flap has been raised from fascia and slid upward into new position, there is no difficulty in closing the defect in the abdominal wall with interrupted sutures. It is surprising how much skin can be used for the flap and sufficient remain to close up the defect in the abdominal parietes without much tension. Size and shape of the abdominal skin flap will depend upon size and form of the raw surface on the chest wall.

The abdominal skin flap is necessary only in those cases in which the defect left after radical amputation of the breast cannot be closed by any of the methods ordinarily in vogue; it is useful after extensive removal of skin and makes skin grafting unnecessary. Nothing especially original is claimed for this plastic operation, but I believe that it should be considered the typical procedure in many cases.

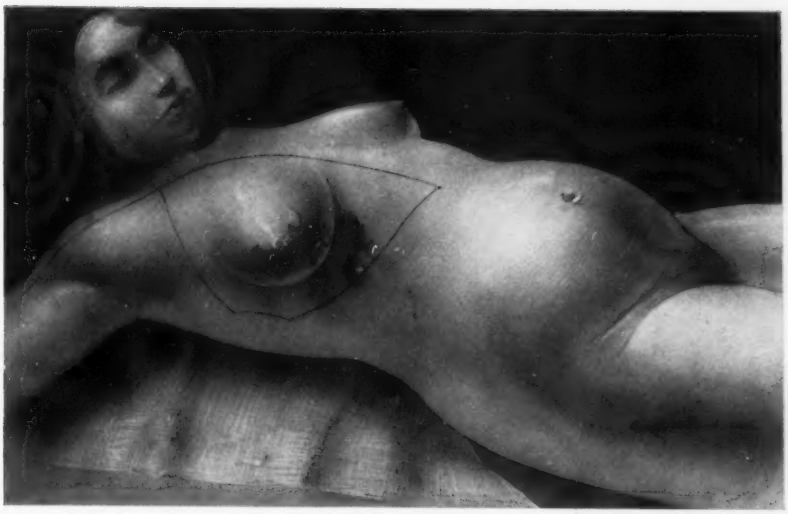

FIG. 1.—The skin incision for the removal of the breast and the diseased skin.

FIG. 2.—Part of the wound has been sutured. The abdominal flap is shown in outline.

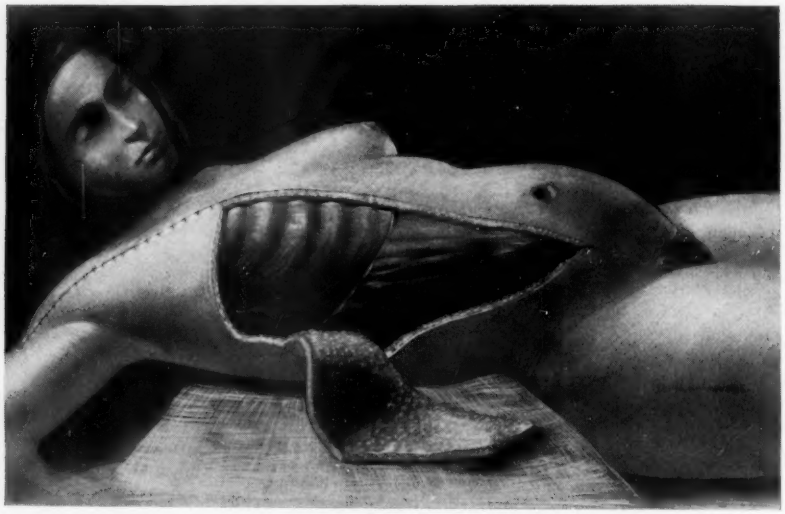

FIG. 3.—The abdominal flap of skin and fat has been raised.

FIG. 4.—The abdominal flap in its new position and the entire wound closed by suture.

SPLENECTOMY FOR SPLENIC ANÆMIA IN CHILDHOOD AND FOR THE SPLENIC ANÆMIA OF INFANCY*

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It is my purpose to lead, not to confusion, but rather to a distinction and a comparison by discussing in the same paper the adult form of splenic anæmia as it occurs in childhood and the splenic anæmia of infancy (anæmia pseudoleukæmica infantum). Anæmia pseudoleukæmica infantum, or von Jaksch's disease, seems to have no relationship clinically or pathologically to leukæmia, and it is agreed by such authorities as Wentworth,[1] Hutchison [2] and Ostrowsky [3] that this terminology should be discarded and the disease referred to as infantile splenic anæmia or the splenic anæmia of infancy. The adult form of splenic anæmia as it occurs in children and the splenic anæmia of infancy have many characteristics in common as well as certain distinctive differences.

The blood of children and particularly the blood of infants under two years of age differs normally from the blood of adults (Shaw [4]). A moderate leukocytosis which is essentially a lymphocytosis is quite constant and marrow-cells are occasionally observed. A lymphocyte percentage of 40 and 50 in infants under two years of age is observed normally and this normal lymphocytosis is always to be taken into account in the consideration of any case of infantile anæmia. It is also generally recognized that the blood of infants reacts differently than the blood of adults to various toxic agents. A lower red cell count with a consequent higher color index, the occurrence of degenerated red cells, the presence of normoblasts and occasional megaloblasts, and a leucocytosis of 10,000, 15,000 or 20,000 with the occurrence of eosinophiles and myelocytes, are frequently present in the anæmias of infancy.

The splenic anæmias of childhood and infancy have been divided by Hunter,[5] chiefly according to the blood picture, into three types. *Type one* corresponds to the clinical picture of the splenic anæmia of adults. There is a large spleen, a gradually developing or recurring anæmia, and the blood presents the picture of a secondary type of anæmia with a relatively low color index and an absence of leucocytosis. Lymphocytes are present in a normal percentage, 40 or 50 per cent., and there is only an occasional normoblast to be found. Hunter's *type two* includes cases in which the leucocyte count is between 10,000 and 20,000 and in which a variable number of normoblasts and megaloblasts are

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present in the smears. The color index is relatively higher. *Type three* embraces those cases in which the leucocyte count is above 20,000 and great numbers of normoblasts, together with occasional megaloblasts, eosinophiles and myelocytes occur. Authorities seem to agree that there is no essential distinction between types two and three, and it would apparently be best to classify the cases into two groups: First, those conforming to the syndrome of the splenic anæmia of adults with absence of leucocytosis, and second, those conforming to that of the splenic anæmia of infancy and showing a leucocytosis, the presence of a variable number of marrow-cells, and a relatively high color index.

1. *Splenectomy for the Adult Form of Splenic Anæmia in Childhood.*—Reports of cases conforming from a clinical stand-point to the adult form of splenic anæmia and Banti's disease in childhood are not uncommon in literature. Reports of cases of this type in which splenectomy has been done are, however, much less numerous. This discussion will be confined to patients of the first decade.

Gaucher's disease, lymphosarcoma, septic splenomegaly, particularly as associated with endocarditis, and the splenomegalies of syphilis, rickets and hæmolytic jaundice are to be especially excluded in the differential diagnosis of splenic anæmia in childhood. I have been able to collect from the literature five cases in which splenectomy has been done for conditions which conform, some of them imperfectly, to the adult type of splenic anæmia occurring in children under 10 years of age. It is to be regretted that complete pathological descriptions of the spleen cannot be obtained in all of these cases, as the diagnosis is undoubtedly questionable in some of them. Brief descriptions of the collected cases are reviewed and one case of our own is discussed in detail.

Bland Sutton[8] in 1895 performed a splenectomy on a girl aged five years, with an enlarged spleen and anæmia. There was a negative family history and "leukæmia, syphilis, rickets and lardaceous disease were excluded." The spleen weighed 10 ounces. Blood count and pathological description were not given. Eighteen years later this patient seemed to be a perfectly healthy woman.

Luce[10] reported a splenectomy (November 16, 1908) upon a girl aged six years. The case was very carefully studied and conformed quite closely to the syndrome of splenic anæmia. There was no history of syphilis and no familial tendency. The spleen extended 5 cm. below the costal margin and a blood count showed: Hæmoglobin 30 per cent., red-cell count 2,100,000 and leucocyte count 6700. There was considerable evidence of blood destruction with an occasional normoblast in the smears. The spleen weighed 240 grammes; there was a hypertrophy of the follicles, a relative atrophy of the lymphatic elements and marked engorgement of the sinuses. Nine months after operation the patient was in excellent condition.

Sutherland and Burghard[7] reported splenectomy (1910) in a girl aged six

years, in whom the hæmoglobin was 30 per cent., the red-cell count 1,870,000, and the white count 2,400. A very faint jaundice was present. Two months after operation the hæmoglobin was 65 per cent. The spleen showed a generalized hyperplasia and weighed one pound. This case was reported as a splenic anæmia but is referred[8] to as a doubtful case of hæmolytic jaundice.

D'Espine[9] in 1913 reported a splenectomy in a case which he classified as Banti's disease in a sixteen-months-old girl baby. The spleen weighed 201 gms. and showed a diffuse fibrosis. The anæmia was of the secondary type with, a leucocytosis of 16,120 and the presence of an occasional normoblast. The child died six weeks later and at autopsy a glandular tuberculosis was found, but animal inoculation with splenic tissue gave negative results. D'Espine states that Banti's disease of adults probably dates from early childhood in many cases.

Barling[11] reported a splenectomy (February 25, 1914) in a girl aged six years, who had vomited blood 10 weeks previous. The spleen extended 3 inches below the costal margin. The hæmoglobin was 60 per cent., red-cell count 3,600,000 and the white varied from 7,000 to 26,000. This case cannot be accurately classified because of the fact that the differential count and pathological description of the spleen were not given. Death occurred on the fourth day after operation and at autopsy an acute hepatitis was found. Barling also mentions a splenectomy in a boy aged six, by French and Turner,[12] but this case would better be grouped with the splenomegalies associated with syphilis.

In our series of 68 splenectomies for various conditions (September 1, 1915) there has been only one in a patient of the first decade, and this one but a recent case. It will be seen that this case, of which a description follows, corresponding quite accurately from a clinical standpoint to the splenic anæmia of adults.

Case A137566.—F. M. D. A girl two and one-half years of age was first examined August 3, 1915. The family history was entirely negative and anæmia, hæmophilia and splenomegaly were inquired about particularly. There were four other children in the immediate family, all healthy, and the mother had had no miscarriages. The patient had evidently been entirely well until about one month before examination, when suddenly she vomited a large quantity of blood, estimated by the parents at one quart, and the stools became black for two or three days. Strength and color were promptly regained and the patient was soon quite well again. Two weeks before examination a second hemorrhage occurred, less severe than the first. After this second hemorrhage, however, the patient seemed to get progressively paler and weaker. An abdominal mass was found two weeks before examination. Ten days before examination an eruption which seemed to be urticarial in character appeared and disappeared again in 24 hours. There was slight fever at this time but a history of fever at any other time could not be elicited. The

appetite was poor, the bowels were regular and micturition was normal.

On examination the child was found to be thin and very pale. The abdominal mass could be easily identified by its contour and notch, as spleen. It extended to a point below the level of the navel. The liver dulness did not seem to be abnormal. The superficial glands were very slightly enlarged. There was no fever. Wassermann test and Widal reaction were negative. The blood count showed a secondary type of anæmia with a color index of .4 and an absence of leucocytosis. The hæmoglobin was 20 per cent., a red-cell count was 2,010,000. The red cells showed marked anisocytosis and moderate polychromatophilia, and only one normoblast was seen while counting 300 white cells. There was no increase in the fragility of the red cells. The leucocyte count was 4000. A differential count of 300 cells showed polynuclear neutrophiles 22.7 per cent., small lymphocytes 50 per cent., large lymphocytes 12.32 per cent., eosinophiles 12.3 per cent., basophiles 2.3 per cent., neutrophilic myelocytes .3 per cent.

Operation (D. C. Balfour, August 15, 1915).—Splenectomy in this case did not offer any marked technical difficulties, although the risk was apparently considerable on account of the patient's age and the severe degree of anæmia. A left rectus incision was made. The diaphragmatic adhesions rendered dislocation of the spleen somewhat hazardous. A long pack was interposed between the spleen and the oozing diaphragmatic surface to control the bleeding if possible without the necessity for suturing later. The œdematous condition of the tissues made them very friable and the pedicle had to be ligated with especial care. It was thought advisable to leave the hæmostatic pack in place until the incision had almost closed, and this proved efficacious. The patient's recovery from the operation was surprisingly good; there were no complications and she left the hospital on the ninth day.

Pathological Report (L. B. Wilson).—Case A137566, F. M. D. Weight of spleen 110 grammes; slight notch; moderate perisplenitis over convex surface; capsule not thickened; on section, gland somewhat tough showing considerable fibrosis; lymphoid areas well defined and increased in size. Microscopic examination shows moderate diffuse fibrosis (chronic splenitis); pulp 2; lymphoid tissue 3; reticulum 2; endothelium of sinuses 2; pigment 0; amyloid degeneration 0; arteriosclerosis 1.† It will thus be seen that the most marked changes were the increase in lymphoid tissues (non-diffuse) and stroma and the hypertrophy of the reticulo-endothelium of the sinuses. The arteriosclerosis, though small in amount, is of course unusual when the age of the patient is considered.

Subsequent Condition.—Three days following operation the hæmoglobin was 27 per cent., the leucocytes had increased to 14,600, of which

71.3 per cent. were polynuclear neutrophiles, and 76 normoblasts were seen while counting 300 white cells. Future reports will contain the ultimate result in this case.

2. *Splenectomy for the Splenic Anæmia of Infancy.*—The splenic anæmia of infancy as a clinical entity was described by Gretsel [13] in 1866. To this syndrome he gave the name of "splenic anæmia of infants." Somma [14] in 1884 described the same condition under the title of "anæmia splenica infantile." Von Jaksch [15] in 1888 and 1890 brought the disease more clearly to the notice of the medical profession under the name of "anæmia pseudoleukæmica infantum." Many cases of the splenic anæmia of infancy have been reported in the literature, and much discussion has resulted, particularly concerning its relationship to rickets, syphilis and the gastro-intestinal disturbances. It seems to have been clearly shown that for the present, at least, it is useful to regard certain cases of severe secondary anæmia in infancy with marked splenomegaly and a more or less characteristic blood picture as a separate disease entity, in spite of the frequent association of rickets.

Splenectomy for the splenic anæmia of infancy has been performed, as far as I have been able to find, in but 4 unquestioned cases.

Wolff [16] in 1906 operated on a boy baby aged eighteen months, of whom there was a six months' history of illness. The spleen was very large, the blood showed a hæmoglobin of 40 per cent., a red-cell count of 467,000 and a white-cell count of 37,800. The differential count showed a lymphocytosis and the presence of mastcells and eosinophiles. There was a considerable pœcilocytosis and anisocytosis, and many normoblasts and megaloblasts were present. The child was in very poor condition. Ascites was present, the liver was enlarged and an operation was advised as a last resort. Splenectomy was performed July 29, 1905. The spleen weighed 500 grammes and showed an induration of the connective tissue framework, but no enlargement of the Malpighian bodies. There was no increase of lymphocytes in the spleen pulp. By the tenth day after operation the hæmoglobin had risen from 40 to 51 per cent. and the red-cell count from 467,000 to 2,500,000, while the leucocytes were 36,000. Three years after operation this patient was presented before the Deutsche Gesellschaft für Chirurgie in excellent general condition. The blood picture was normal save that the leucocytes had remained increased.

Graff [17] in 1908 reported the case of a fifteen-months-old baby on whom splenectomy had been done in the summer of 1907. The family history was negative, the child had apparently been normal to the tenth month. After this time the appetite failed and the child lost weight, while there was a gradual increase in the size of the abdomen. At the time of the examination the patient was emaciated, scrawny, yellowish-white in color and weighed only 11 pounds. There was evidence of mild rickets. The spleen extended beyond the midline

† The numbers, 0, 1, 2, 3, 4, indicate the relative amounts of the several tissue elements.

and downward almost to the symphysis. The liver did not seem to be enlarged. The blood count showed a hæmoglobin of 45 per cent., a red-cell count of 1,800,000, with many normoblasts and a few megaloblasts. The white-cell count was 37,000 and an examination of the smears showed a lymphocytosis. The spleen measured 16 x 10 x 8 cm., and weighed one pound or nearly one-tenth of the body weight. It was very firm and hard. On examination it showed an increase of connective tissue, occasional hemorrhages and small collections of lymphocytes, and giant-cell-like structures similar to bone-marrow giant cells. There was no evidence of tuberculosis or tumor. After splenectomy the patient began immediately to improve. In 5 weeks the hæmoglobin was 50 per cent. and the red-cell count had risen from 1,800,000 to 5,000,000. In 9 months the patient was quite well, weighed 21 pounds, and the blood was almost normal.

Fowler[18] performed a splenectomy in April, 1914, on a fourteen-months-old girl baby, in whom the spleen was much enlarged, the liver was apparently normal and the blood count showed a hæmoglobin of 50 per cent., a red-cell count of 3,316,000, giving a color index of .9 per cent., with many normoblasts and occasional megaloblasts in the blood smears together with a considerable variation in the size and the staining qualities of the red cells. The leucocyte count was 30,000 with polynuclears of 40 per cent., large mononuclears 12 per cent. and small mononuclears 38 per cent. One month after operation the hæmoglobin was 65 per cent. and the red-cell count 3,430,000, with occasional normoblasts and megaloblasts, the leucocyte count 15,000, of which the small mononuclears was 78 per cent.

Pool[19] performed a splenectomy on a boy baby of nine months on August 17, 1914, after a preliminary blood transfusion of 150 c.c. The infant had been born at 7 months and nutritional disturbances had been troublesome. The child was very poorly developed, anæmic, and showed evidence of rickets. The liver extended 2 cm. below the edge of the ribs and the spleen 5 cm. below the left costal margin. A Wassermann test was negative. The patient had been on preliminary medical treatment for 6 weeks without improvement. The hæmoglobin before operation varied from 30 to 45 per cent., the red count from 1,400,000 to 2,400,000 and the leucocytes from 17,000 to 54,000. A differential count showed polynuclears of 35 per cent., eosinophiles 2 per cent., lymphocytes 49 per cent., transitionals 3 per cent., large mononuclears 6 per cent. and myelocytes 5 per cent. Normoblasts had varied from 6 to 66 per 100 white cells and of these 2 or 3 were megaloblasts. Two months after operation the hæmoglobin had risen to 85 per cent., the red-cell count to 4,200,000 and the white-cell count had decreased to 13,300. The high lymphocyte percentage persisted but the normoblasts were decreased in number. Three months after operation the patient was reported to be not as well as he had been at 2 months.

None of our cases of the splenic anæmia of infancy has so far been operated on and my purpose in collecting these 4 instances of splenectomy for the splenic anæmia of infancy is to call attention to the fact that excellent results have been obtained in very severe types of the disease. Wolff's patient was in excellent condition 3 years after operation, Graff's patient had improved markedly 9 months after operation and Fowler's patient was in satisfactory condition one month after

operation. Pool's patient showed remarkable improvement for 2 months and at 3 months was reported as in a less satisfactory condition, but it must not be lost sight of that his patient was a premature child and had developed very poorly. It is emphasized by Wolff that splenectomy should for the present be reserved for severe cases of the disease. The milder types improve upon medical treatment, but the severer types die, usually of some intercurrent affection.

Discussion.—An excellent conception of the varied types of disease in which anæmia is associated with chronic enlargement of the spleen in children and infants can be obtained from the several papers by Wentworth,[1] in which are given excellent reviews of reported cases. Wentworth concludes that the splenic anæmia of infancy is a secondary anæmia and in no way related to leukæmia. He also infers that the adult form of splenic anæmia may be a prototype of the splenic anæmia of infants. Hutchison [2] collected 22 cases of the splenic anæmia of infancy in patients from 9 months to two and one-half years of age. Ostrowsky [3] reports 10 cases of his own, varying in age from 7 months to 2 years with leucocyte counts of from 8000 to 25,000. Carpenter [20] in a review of 348 patients with splenomegaly, under 12 years of age, places rickets first and syphilis second in the etiological rôle. Ashby [21] concludes that the toxin causing rickets may also cause the splenic anæmia of infancy and that the reported cases vary from those with marked bone changes and small spleen to those with slight bone changes and a very large spleen. Carr [22] draws attention, however, to the following facts: First, that in a majority of rickety children there is no splenic enlargement; second, that there is no connection between the severity of the rickets and the size of the spleen or the degree of the anæmia; third, that in certain cases of the splenic anæmia of infancy there is no evidence, whatever, of rickets. The general experience seems to indicate that, granted the frequent association of rickets, there are yet certain cases which, on account of their marked splenomegaly and their severe anæmia, their evidences of extensive blood destruction, and a reversion to the fetal type of hæmopoiesis should, for the present at least, be grouped together as a separate disease entity.

Reports of cases of the adult form of splenic anæmia occurring in children under 2 years of age are very difficult to find, while the splenic anæmia of infancy seems practically never to be present in patients over the age of two and one-half years. This observation is in itself suggestive of the possibility that some relationship may exist between the two diseases. The chief clinical distinctions between the adult form of splenic anæmia and the splenic anæmia of infancy are in the blood

picture, and chiefly the characteristics of the leucocyte count. In the splenic anæmia of infancy there is more evidence of blood destruction than in the splenic anæmia of adults; the red-cell count is likely to be lower and the color index consequently higher, and normoblasts and megaloblasts are present in the blood smears. In the adult form of splenic anæmia there is an absence of leucocytosis while in the splenic anæmia of infancy there is a notable leucocytosis, which is, however, in reality a lymphocytosis. Our knowledge concerning the normal blood of infants and the reaction of the infant's blood to various toxic agents would lead us to regard these differences as less surprising. And especially does the biological fact that infancy is a transition period, in which there may be reversions to the fetal type of hæmopoiesis, have a bearing upon the variations in the infantile type of splenic anæmia. In addition to the above characteristics, we now have also the knowledge that splenectomy has been followed by excellent results in both conditions. These facts would suggest the possibility that the splenic anæmia of infancy may be a similar condition to the splenic anæmia of adults and that the differences may be largely due to the peculiar reaction of the infants' hæmopoietic system to the etiologic factor in the disease. For the present, and until our knowledge is much fuller, a sharp distinction should be drawn between the two conditions.

SUMMARY.—1. The normal lymphocytosis of the infants' blood and its decided reaction to various toxic agents is always to be taken into account in the consideration of any case of infantile anæmia. Infancy is a transition period during which a reversion to the fetal type of hæmopoiesis is likely to occur.

2. The adult form of splenic anæmia as it occurs in children and the splenic anæmia of infancy have many characteristics in common, and also certain distinctive differences.

3. There is sufficient evidence to indicate a close relationship between the adult form of splenic anæmia as it occurs in childhood and the splenic anæmia of infancy. Until our knowledge is fuller, however, a sharp distinction should be drawn between the two diseases.

4. Splenectomy has been performed in only a few instances of the adult form of splenic anæmia occurring in the first decade of life. One case of this character is reported herewith. There is a doubt as to the exact diagnosis in some of the seven cases collected from the literature.

5. A review of the literature of the splenic anæmia of infancy (anæmia pseudoleukæmica of von Jaksch) shows that splenectomy has been performed in 4 instances of severe types of the disease, with marked immediate improvement.

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PRIMARY SARCOMA OF THE GALL-BLADDER

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A review of the literature leads to the conclusion that primary sarcoma of the gall-bladder is an exceedingly rare disease. According to Iwasaki,[1] who recently reported a case and at the same time presented a synopsis of the earlier publications on the subject, there are only eight well-authenticated cases which have been described up to the time his paper was written. It is possible, however, that primary sarcoma of the gall-bladder is of more frequent occurrence. In some of its details the tumor may bear a close resemblance to primary carcinoma of the gall-bladder; and, therefore, among the large number of inoperable tumors of the gall-bladder found on exploring the abdomen, it is not unlikely that the two types of tumor have at times been confused.

The following case of sarcoma of the gall-bladder occurred in a woman thirty-eight years old who entered the St. Louis Mullanphy Hospital, May 14, 1915, on account of severe pains in the upper part of the abdomen and back. An abstract of the history follows: She was a housewife, married, German. Her father and mother were dead, the cause unknown. There was no history of cancer or tuberculosis. The patient was always well until three years ago when her present sickness commenced. The illness began with pain in the right upper quadrant of the abdomen and back. Attacks of pain continued at intervals up to time of entrance into the hospital, having increased in severity and frequency during the last six months. The pains required morphine for relief. At no time was the patient distinctly jaundiced, although she believed that on several occasions her skin was slightly yellow. She had experienced occasional nausea, and once in a while had vomited a bitter-tasting fluid. She lost about twenty pounds in weight during the last six months.

The patient was poorly nourished. Sensorium was clear. The skin was moist and cool. The teeth were in bad condition. A few small glands were felt on right side of the neck. The chest was poorly developed, but the heart and lungs were normal. The liver seemed somewhat enlarged, with moderate tenderness over the region of the gall-bladder. No tumor was felt. The entire

abdomen was held rigid. There was no fever and the pulse was normal. The urine was clear in color and had a specific gravity of 1030. The urine showed a slight trace of albumen; but bile was not present. The examination of the stools was negative. A gastric analysis was made thirty minutes after giving a glass of water and two slices of bread. One hundred and twenty cubic centimetres of gastric contents were returned. This showed a trace of free hydrochloric acid. The total acidity was twenty-nine. The blood examination was normal. A radiograph of the abdomen showed no abnormality.

Operation (May 21, 1915).—The incision was made in the median line. Upon opening the peritoneum the distended gall-bladder sprang into the wound. The gall-bladder appeared much enlarged and felt thickened, due to an infiltration of its wall with a tumor mass. Calculi were felt through the wall of the gall-bladder. The liver seemed somewhat enlarged, but otherwise looked healthy, except at the site of the gall-bladder where the tumor had slightly invaded its substance. A careful search of the entire abdominal cavity showed no tumor tissue other than that of the gall-bladder, justifying the assumption that the neoplasm was primary in this organ. A cholecystectomy was done and the part of the liver invaded with tumor tissue was removed with the gall-bladder. As there was some oozing of blood from the wound, a drain was introduced and the abdomen closed except where the drain protruded. For two days after operation the patient did well, but on the third day she suddenly commenced to fail and continued to do so until May 25, when she died. Consent for the autopsy was not obtained.

The gall-bladder with the tumor attached weighs 69.5 grammes and measures 11 cm. in length and 4 cm. in width. The fundus of the gall-bladder appears considerably œdematous; its outer surface is of yellowish-gray color.

Occupying the central part of the gall-bladder and extending in the direction of the cystic duct is a large irregular tumor measuring 8.5 x 4 x 3 cm. The mass is formed principally by two large knobs of unequal size; the larger is found in the region of the fundus, while the smaller is found near the beginning of the cystic duct. The knob-like masses are connected by a broad ridge of tumor tissue which lies in the substance of the gall-bladder. On opening the gall-bladder a small amount of yellowish bile is noted. In the fundus are twelve faceted gall-stones, measuring 1.5 cm. in the longest diameter.

The mucous membrane of the gall-bladder appears to be intact. The small irregular folds are somewhat thicker than normal, and at several points in the fundus minute polyp-like projections are formed. Where the tumor has its greatest diameter, the mucosa appears smoother than usual, as if stretched by the underlying mass. On section, the

tumor is found lying directly below the mucous membrane, replacing the normal structure of the wall (Fig. 1). The tumor tissue is smooth, homogeneous, and of dull white color. It feels firm but not hard. In several circumscribed areas, deep in the substance of the mass, a softening has occurred. Such areas are microscopically found to be regions of widespread necrosis. Necrotic areas contrast sharply with other parts of the tumor as they appear as yellowish-white points in a white field. The nodular mass near the cystic duct presents several wide areas of necrosis, the largest of these measures 2.5 cm. in diameter. A pink zone of hyperæmia surrounds the necrotic tissue. No points of hemorrhage are noted.

In the region where the tumor is massive and has replaced normal structures, the wall of the gall-bladder measures 3 cm. in thickness. In that part of the fundus where tumor tissue does not exist, the wall of the gall-bladder has a thickness of 4 mm.

Histologically, the tumor is a sarcoma composed chiefly of round cells (Fig. 2). These vary somewhat in size but measure, after fixation in 10 per cent. formaldehyde, usually 10 microns in diameter. The nucleus of the cell is round or slightly oval, rich in chromatin and contains frequently a nucleolus. The nucleus has an average measurement of 7 x 7 microns. The cytoplasm of the cell is clear or slightly granular and usually abundant in amount. Less frequently the cytoplasm is scanty and surrounds the nucleus as a narrow ring. The nucleus of cells containing a small amount of cytoplasm is found to be small, measuring 5 microns, and is more deeply stained. In several sections the tumor cells assume here and there a spindle shape. Spindle-shaped cells are always few in number and found in small groups. These cells measure 18 microns in length and 5 microns in width and contain a nucleus 13 microns long and 4 microns wide. Multinucleated cells or giant-cells are not found. The stroma of the tumor consists of a network of fine fibrile and delicate connective tissue supporting small capillaries. Mitotic figures are present in considerable numbers; irregular forms of mitosis are extremely rare. In the sections areas of necrosis seem to be more plentiful than the gross inspection of the tumor indicates. Besides the places in the tumor as already mentioned, where widespread necrosis has occurred, numerous small fields of necrosis are found on microscopical examination.

Save for the epithelium of the mucous membrane, the wall of the gall-bladder at the site of the tumor has been replaced in great part by tumor tissue. In the midst of large masses of tumor cells, occasional strands of muscle tissue are found. These are often necrotic and are the remains of the muscularis. Small bundles of hyaline connective tissue are also found scattered throughout the sections.

In one section deep in the substance of the tumor, small tubules lined with columnar epithelium are noted, which probably represent remnants of the epithelial crypts of Luschka.

A well-defined chronic inflammation exists in all parts of the gall-bladder. The inflammatory changes involve chiefly the mucous membrane whose folds are thickened and project in a polyp-like manner into the lumen of the gall-bladder. The epithelium in places has formed numerous small superficial tubules which resemble glands in their structure. Lymphoid

FIG. 1.—Gall-bladder, showing the sarcoma lying below the mucous membrane, replacing the deeper structures of the wall of the gall-bladder.

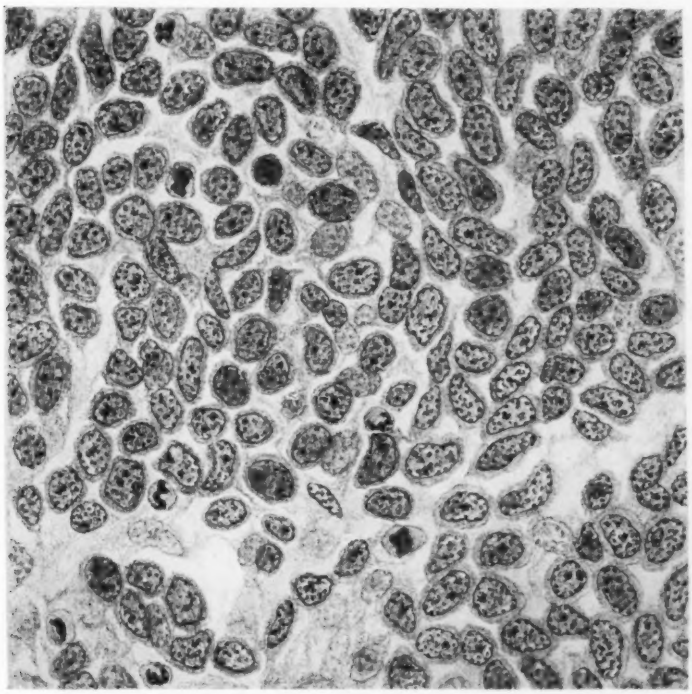

FIG. 2.—Microscopic drawing of tumor (x300). Round cells, at times slightly oval, form the predominant cell of the tumor.

cells and plasma cells are present in large numbers infiltrating the interglandular tissue. In many places polynuclear leucocytes and large numbers of eosinophile cells are found.

The predominant cell of the sarcoma here described is a round cell, although occasionally spindle-shaped cells are found. The histological character of the tumor appears to differ in this respect from that of primary sarcoma of the gall-bladder in cases already reported which have often presented a more complex cellular structure. Thus, the case described recently by Iwasaki was polymorphous in character. The tumor, measuring 10 cm. by 4.5 cm., was composed of long spindle cells, large round cells, small round cells and many giant cells. Two cases reported by Landsteiner [2] are described as myosarcoma. The predominant cells in both tumors were of the spindle type, yet numerous cells were found intermingled with spindle cells, which were regarded as smooth muscle. In one of the cases described by Landsteiner there existed in the gall-bladder, beside the sarcoma, an epithelioma which had arisen as a metaplasia of the mucous membrane and was invading the deeper structures of the wall.

Parlavecchio's case [3] was a spindle-cell sarcoma which presented many multinucleated cells as well. In places the tumor assumed the characters of mucinous tissue and was composed of star-shaped cells presenting fine anastomosing processes. The case of Hotes [4] was a spindle-cell sarcoma. Bayer [5] reported two cases. The first of these was a sarcoma composed chiefly of spindle cells, although in numerous areas round cells were found as well. The second case was a spindle-cell sarcoma with multinucleated giant cells. One of Landsteiner's cases contained in places hyaline connective tissue which had undergone calcification. In the second case reported by Bayer, islands of cartilage and bone were found.

The size of the tumor has varied considerably in the different cases of sarcoma of the gall-bladder which have been described. The tumor reported in this communication appears to be relatively small and measures only 8.5 cm. in its greatest diameter. The sarcoma described by Landsteiner reached the diameters of $19 \times 4 \times 8$ cm., filling the right side of the abdomen. The sarcoma of the gall-bladder, while still moderately small in size, is apparently confined to tissue below the mucous membrane, resembling in this regard the sarcoma of the stomach. In tumors of larger size, an invasion of the mucous membrane with tumor tissue occurs. In the case of very large sarcomas of the gall-bladder, the tissues of the gall-bladder itself can be identified

with difficulty as scattered remnants, or, indeed, may not be recognized at all. Large tumors are usually in the form of thick-walled cystic masses whose central cavities contain purulent fluid with necrotic tissue in which gall-stones may be found. There is a curious tendency in some of the tumors which have been described to grow in the direction of the cystic duct. The tumor under these circumstances projects as a conical mass into the lumen of the gall-bladder, the apex of the growth extending toward the cystic duct.

Invasion of the substance of the liver is common even in the case of small tumors. The involvement of the liver by an extension of the growth from the gall-bladder may become very great. Metastases into the liver at points distant from the gall-bladder have been described. In Landsteiner's case the metastatic masses were as large as 10 cm. in diameter. Metastatic growths in other organs were also recorded. In the case of Hotes, the diaphragm was involved and the duodenum was imbedded in a mass of tumor tissue; while the mesenteric and pelvic lymph-glands, the appendix and the spleen showed nodules of tumor tissue. In Landsteiner's case, the neck of the gall-bladder was adherent to the duodenum, and two points of communication between gall-bladder and duodenum were noted. In several of the cases described there had been associated with the tumor of the gall-bladder a peritoneal exudate.

In all cases cited by Iwasaki, gall-stones were found except in one. As to whether stones precede or follow the development of the tumor, there is no certain way of determining. In the case here reported, the continuance of the symptoms of gall-stones for three years and a relatively small tumor which presented histologic evidence of rapid growth, makes it seem likely that the formation of stones and a chronic inflammation of the gall-bladder existed before the development of the tumor. At all events, it is probable that the development of the gall-stones preceded the period when the tumor assumed an active and invasive growth.

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RESECTION OF THE CARDIA FOR CARCINOMA*

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Before starting my remarks on the resection of the cardia for carcinoma I almost feel like apologizing for writing this paper on the basis of two operations, the outcome in both of which was fatal. However, I am so absolutely convinced, not only of the technical possibility of the work in all its varieties, but also of the possibility of a more frequently successful issue than has hitherto been obtained, that I venture to submit my experience to you.

It is a well-known fact that the œsophagus has four places of stricture, physiologically:

1. Near its very beginning, behind the cricoid cartilage at the neck.
2. Behind the bifurcation of the trachea.
3. At the hiatus œsophageus of the diaphragm.
4. At the cardia.

As in other portions of the gastro-intestinal tract, it is for the very places of physiological stricture that cancer seems to have a predilection. No doubt the manifold lesions, to which these spots are continuously subjected by the ever-recurring descent of the chewed food, favor its development in patients cancerously inclined.

To differentiate cancer of the œsophageal hiatus from that of the cardia may be correct from a pathologic point of view; clinically it is not so. v. Hacker pointed this out years ago and proposed combining the two types under one heading.

Expressed in percentages and round figures the frequency of cancer of the œsophagus with reference to location is as follows: Neck, 10 per cent.; bifurcation, 40 per cent.; hiatus, 27.5 per cent.; cardia, 22.1 per cent.; or, the latter two combined and grouped under the common head of "cancer of the cardia," almost 50 per cent., one-half of the cases. If we add to these the malignant tumors that grow at the lesser curvature, near the cardia, and clearly belong to this group, at least from an operative point of view, it will become evident that cancer of the cardia is not a particularly rare disease. And cancer of the œsophagus takes the fifth place in the table of frequency of all carcinomas.

Within the last decade cancer of the cardia, with other malignant

* Read before the American Surgical Association, June 10, 1915.

œsophageal strictures, has passed within the scope of operative surgery. Attempts at its resection have often been made. The first successful case dates back seven years.

A perusal of the literature shows that so far five cases have made an operative recovery. Every one of them was treated by a different plan of operation.

Case I.—Voelcker of Heidelberg, in 1908,[1] operated on a female, aged sixty-two years, entirely by way of the abdomen. With the help of an oblique incision from the ensiform process to the axillary line and division of the seventh cartilage near the sternum, free access was gained to the seat of the trouble. He was so fortunate as to find the cardia descended and the normal œsophagus running for 2 cm. within the abdomen, proximal to the malignant stricture. After having mobilized the œsophagus at the diaphragm he could pull the tumor down for another 4 cm. Thus it proved feasible to work within the abdomen throughout. He resected the tumor and united the divided ends of the œsophagus and the stomach by Billroth's method No. 1 (Fig. 1). Gastrostomy was added and the region of the operative field tamponed. There was some leakage at the anastomosis for four weeks, during which time the patient was nourished through the gastric fistula. Then union became perfect. The fistula closed at the end of the seventh week, when the patient left the hospital. A week thereafter she was able to swallow any kind of food and had greatly improved in general health.

Voelcker operated upon two other patients for the same trouble. Both died. In one the adherent spleen had to be excised; Murphy's button was used for the anastomosis; leakage on eighth day; death on twenty-fourth day after operation.

In the other case the cardiac tumor was pulled through an incision in the posterior wall of the stomach after gastrotomy; mucosa sutured from within, seromuscular from without, the tumor being gradually cut off. The various steps could be nicely and exactly carried out; death twenty-four hours later.

Autopsy showed chronic granular nephritis.

Case II.—The second successful case was reported by Kuemmell, of Hamburg, and operated in 1910.[2] He, too, worked entirely by way of the abdomen, under venous ether anæsthesia. After mobilization of the tumor within the diaphragm, he could pull the œsophagus down for a distance of 10 to 12 cm. (!). Direct union appeared possible. Murphy's button was introduced, but its halves could not be closed. There was too much tension. Button was removed. In this emergency the only way out of the dilemma was to tie a rubber tube into the œsophagus, letting the other end of the tube pass out of the abdominal wound. Part of the hole in the stomach was used for gastrostomy (Fig. 2, diagrammatic). Tamponade. Gradual contraction of the wound, bringing the two openings closer and closer; introduction of a rubber T-tube, with which patient was able to swallow (Fig. 2). The T-end was to be used in case any difficulty in direct swallowing should arise; it did not come into use. At the time of the report, ten weeks after the operation, a small fistula still had to close up; the patient had greatly improved.

[1] Verhandlungen der Deutschen Gesellschaft f. Chir., 1908, vol. i, p. 126.

[2] Verhandlungen d. Deutschen Gesellschaft f. Chir., 1910, vol. i, p. 96.

In another case, done by Kuemmel a few years before, also with Murphy's button, leakage caused peritonitis and death.

It seems to me that Voelcker's and Kuemmell's experience must be looked upon as rather exceptional. We certainly shall not be able, in the average case, to pull the œsophagus and cardia down into the abdomen for a sufficient distance to enable us to do the entire resection within the abdominal cavity, because the lower portion of the œsophagus will usually be found more or less involved in the disease.[3] The healthy portion of the œsophagus above the upper end of the tumor can then not be reached from below with sufficient ease to insure good surgery.

It is in these cases that abdominal and thoracic surgery join hands. Not infrequently one or both pleural cavities will have to be opened. We must therefore be prepared, and make the necessary arrangements to overcome the dangers of an acute pneumothorax. Any one of the three principal methods of avoiding it by means of differential pressure can be used, most conveniently intratracheal insufflation.

Referring to the experience of Voelcker and Kuemmell with the Murphy button in their attempt at immediate union between œsophagus and stomach, one can well understand how this otherwise useful button should fail in these cases for the reason that the œsophageal muscularis has no serous cover. Tiegel's button satisfactorily answers the requirements, as it was designed for this particular class of cases. After approximation, the field of operation is invaginated into the stomach.

Case III.—Sauerbruch made use of this device in a case of circumscribed malignant infiltration of the cardia.[4] He worked through the thorax and, after excision of the tumor and suture of the stomach, could pull the latter up sufficiently into the chest, to accomplish a good anastomosis (Fig. 3). The patient recovered from the operation, but contracted a right-sided pneumonia on the fourteenth day, to which he succumbed. Autopsy showed a perfect operative result without infection of pleura or mediastinum.

[3] Nunberg, of Navarro's Clinic at Genoa, recently published an article (Beitr. f. klin. Chir., Bd. 95, Hft. 3, March, 1915) in which he points out the erroneousness of the belief held by some, that we can pull down the œsophagus for a distance into the abdomen in the presence of a tumor at its entrance into the stomach. He believes that without loosening the œsophageal adhesions farther up in the posterior mediastinum, downward traction will prove ineffectual, and that the upward displacement of the diaphragm at the foramen œsophagæum (with hand or retractor) alone is responsible for better access to the upper portion of the œsophagus. Personally, I believe that Nunberg's views are correct in part. Further clinical observations will throw more light on this interesting question.

[4] Technik d. Thorax Chir., 1911, p. 87.

Sauerbruch was fortunate in having a case in which, after resection, he could transpose the stomach upward sufficiently into the thorax to enable him to do an immediate anastomosis without undue tension.

These cases are the exception, however; not the rule. At the stage in which patients usually reach us at the present time they require wide removal, so that direct union is out of the question. Besides, during primary gastrostomy the pyloric portion of the stomach is fastened to the anterior abdominal wall, and renders illusory any attempt at pulling the cardiac portion up into the thorax for a safe anastomosis.

For these advanced cases a method has been worked out in the course of the last years, which promises to become standardized. This is a 2- or 3-stage operation which consists in:

(*a*) Gastrostomy with careful palpation of the conditions at and around the cardia.

(*b*) Excision of the tumor, at the same time construction of a new exit for the proximal (oral) stump of the œsophagus.

In weak patients and cases with extensive involvement of the œsophagus, this second stage may have to be divided once more, so that the operation will become a 3-stage one.[5]

The lower end of the proximal stump may be led out laterally in the axillary line, while the upper portion remains *in situ* and undisturbed within the posterior mediastinum, or the entire proximal portion of the œsophagus is removed from its normal place in the posterior mediastinum and placed antethoracically under the skin of the left side of the chest: partial superior œsophagoplasty.

Case IV.—J. H. Zaaijer, first assistant to the Surgical Clinic at Leiden, Holland, reports a successful transpleural resection of the cardia, 1912, in which the lateral exit of the œsophagus was chosen.[6]

Male aged fifty-four years; 3-stage operation:

First stage: Exploratory laparotomy to ascertain the operability of the carcinoma; establishment of a gastric fistula (Kader).

Second stage: Subperiosteal resection of long pieces of the sixth to twelfth ribs.

Third stage: One month later, under positive differential pressure: incision of peritoneal and left pleural cavities; resection of cardia; closure of stomach wound. Mobilization of proximal œsophageal portion, suturing its cut surface into parietal pleura and skin within an axillary line-incision. Fig. 4 represents condition of patient twenty-two days after operation. The rubber tube, connecting œsophageal with gastric fistula, enabled the man to take liquid and semisolid food by mouth.

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[5] Cf. author, Centralbl. f. Chir., 1914, Nos. 2 and 32.

[6] Beitr. z. klin. Chir., vol. lxxxiii, 2.

Zaaijer's excellent work and its successful outcome must command our admiration. But to provide a lateral exit of the oral œsophageal stump does not seem to be the most desirable procedure. The gastric fistula is usually established anteriorly through the left rectus muscle. In the Beck-Jianu method of gastrostomy, which includes partial inferior œsophagoplasty by making use of the major curvature of the stomach,[7] is the opening of the new tube that leads down into the stomach also placed anteriorly on the left side of the chest, at a level with the fourth to second rib cartilage or still higher. It therefore seems but rational to try to have the exit of the proximal œsophageal stump anteriorly in the parasternal, not laterally in the axillary line. Ach's and Torek's successful cases prove that this method, first proposed by v. Miculicz and Kelling, in 1904, and so splendidly worked out experimentally by Ach, of Munich,[8] is a useful one and deserves our most earnest attention.

CASE V.—Male, aged fifty-two years; operated upon by Ach on June 7, 1912, with resection of the cardia, a most important case, marking, I believe, a mile-stone in the evolution of œsophageal resection. Ach did the whole operation, including gastrostomy, in one sitting, in the stupendously short time of one hour and twenty-five minutes. Fig. 5 illustrates the extent of the resected tumor. However, the principal addition Ach has made to œsophageal surgery for carcinoma is his method of extracting the tube from the posterior mediastinum, which greatly simplifies the transposition of the proximal stump, after resection of the stricture in any part of the œsophagus. Details of the procedure are given below.

Some authors consider the extraction of the œsophagus through a wound at the neck a dangerous procedure, because the nourishing arteries of the œsophagus, which are derived directly from the aorta, have to be torn and may give rise to secondary hemorrhage. This has been more recently emphasized by A. Hirschman.[9] However, Ach's multiple animal experiments plus three operations on the human subject, in none of which secondary hemorrhage occurred, seem to refute the fear expressed, and furnish a strong argument in favor of this easy and simple extraction method.

Rehn, Jr., advises extractions of the inner layer of the œsophagus only, leaving the muscularis in place.[10] This may well be done in a healthy dog, but how it could prove practical in the case of a sick human

[7] See author, ANNALS OF SURGERY, September, 1913; Jour. Amer. Med. Assn., January 10, 1914; Surgery, Gynæcology and Obstetrics, February, 1915.

[8] Beitr. z. Œsophagus Chirurgie, München, 1913.

[9] Beitr. f. klin. Chir., March, 1915, vol. xcv, 3, p. 469.

[10] Œsophagus Chirurgie, Jena, 1914.

being with an œsophagus harboring a malignant tumor in all its layers is hard to see.

Ach's first patient treated with extraction of the œsophagus made a splendid operative recovery, but, unfortunately, died in consequence of leakage of the gastric fistula on the seventeenth day after operation. Autopsy proved an ideal result of the cardiac resection and of the œsophageal transposition. Ach reports two additional operations of this type done on men fifty and fifty-four years old, in which the same plan was followed. Both patients died of pneumonia, one of additional mediastinitis on the fourth day after the operation. Both are of interest, inasmuch as the pyloric portion of the stomach, which, after resection and suture, had the shape of a longitudinal tube of 12 to 15 cm. in length and somewhat more than a thumb's size, was made use of for inferior œsophagoplasty according to the Beck-Jianu method. This brought the entrance into the stomach up to a line above the mammillæ and obviated the dangers of possible leakage of a typical gastric fistula, established at the same sitting.

Ach expects to be able to remove all œsophageal carcinomas situated below the aortic arch by way of the abdominal route, with extraction of the proximal stump according to his method. He is not in favor of the transpleural route which, of course, permits of exact surgical work under the guidance of the operator's eyes, but on the other hand involves protracted work within the pleural sac. Further practical experience in man will have to decide the advantages or disadvantages of the different advances. Most likely both procedures will have a lasting place in œsophageal surgery.

The details of Ach's method will be seen from the description of the two operations done by me, in which I tried to follow his steps as much as cases and conditions warranted.[11] The technical difficulty in both was that the operation had to be done in the presence of a gastric

[11] In justice to Ach as well as for the sake of completeness I shall briefly outline the sequence of the various steps of the operation as done by him. No primary gastrostomy; single-step operation. Left oblique abdominal incision; thorough exploration of tumor and operating field; exposure of œsophagus at neck; tamponade of this wound. Isolation of tumor beneath diaphragm; preparation made for use of positive pressure (Brauer's apparatus). Both pleural cavities had to be opened; cutting of nervi vagi above tumor; application of clamp about three-quarters inch above same, perforation of œsophagus at upper edge of clamp with needle and long linen thread; ligation; second clamp to tumor, division of œsophagus between. Ligation of omentum minus, inclusive of left superior gastric artery; clamped cardia covered with gauze compress; extraction and transposition of proximal stump as described in this article; fixation of rubber tube in projecting portion in front of skin wound; closure of neck wound

fistula, the integrity of which had to be preserved at all hazards. None of the five surgeons, mentioned above, had to deal with this complicating feature.

The feasibility of such preservation of the gastric fistula, when operating on the cardia, I could prove years ago, in a boy, aged fourteen years, who had an absolutely impermeable cicatricial stricture of the œsophagus since his sixth year. Entrance into the stricture from above with the help of œsophagotomy had proved futile. I therefore tried the retrograde way with the help of the osteoplastic resection of the costal arch and gastrotomy, without, however, carrying my point. The bone flap was replaced and the patient made a good recovery with preservation of perfect function of the gastric fistula (Fig. 6).[12]

PERSONAL EXPERIENCE.—CASE I.—Man, aged fifty-four years; Post-graduate Hospital; service of Dr. L. Kast, who very courteously referred the patient to me for operation. Typical cardiac stenosis; the presence of which had been proven by all modern means. Wassermann negative; but patient had specific infection when young. Œsophagoscopy omitted, because bougie had caused marked subjective trouble and the stenosis demanded prompt relief. Gastrostomy (Witzel), December 15, 1914. Palpation done on this occasion revealed an irregular, nodular, circular tumor, the size of a lemon, below the diaphragm, and a number of infiltrated glands near either curvature; no secondary deposits elsewhere palpable; the mass was well movable, not adherent to diaphragm or spleen.

The tumor was undoubtedly operable. I am sure every surgeon would have found the strict indication for resection, had a tumor of the same size and character been found at the pylorus. So I decided to go ahead.

After forced feeding through gastric fistula with self-masticated food for a few weeks, January 19, 1915, radical operation. First assistant, Dr. M. Rehling; intratracheal insufflation (Dr.

by layer sutures. Change of rubber gloves. Careful mopping of posterior mediastinum; suturing of the muscle bundles, which surround the hiatus œsophageus and of the covering diaphragmatic peritoneum. Ligation and division of omentum majus and the rest of omentum minus, distal to infiltrated lymphatic glands; transverse resection of stomach at a safe distance from the distal end of the tumor; closure of stump; layer suture of abdominal wound, fastening stomach at inner angle of latter where the rubber tube in a Witzel's gastrostomy is made to emerge; dressing of neck, thoracic and abdominal wounds.

[12] See Med. News, October 29, 1904, and Jour. Amer. Med. Assn., October 6, 1906, Osteoplastic Resection of the Costal Arch in Order to Reach the Vault of the Diaphragm.

C. Eggers). Stomach lavage; rubber tube removed from gastric fistula and canal blocked with a tampon of iodoform gauze and covered with sterile strips of zinc adhesive plaster, which were thoroughly iodined. Pronounced lumbar lordosis on sand bag; second bag under left hip, producing a moderate right lateral posture. An operating table of the newest construction will greatly assist in producing the desired posture (Figs. 7 and 8). If still no satisfactory access can be had, Kelling's posture might be tried [13] (Fig. 9). Oblique skin incision, parallel to left border of ribs and then up into axillary line, carefully avoiding interference with gastric fistula (Fig. 10). (The gastric tube was left in place in the illustration in order to emphasize the presence of the gastric fistula.) Division of muscles; blood-vessels ligated; opening of abdomen. As seen before, in an operation on the cadaver, access to the cardia was unsatisfactory without division of the left rectus muscle. This, however, was not feasible here on account of the necessity to preserve the gastric fistula. Therefore resection of twelfth and eleventh ribs, which makes tissues somewhat more movable. Tumor was of same size as five weeks previously.

Place for transverse division of stomach selected and major omentum ligated and divided toward cardia, including infiltrated glands and vasa brevia in front of spleen; the latter can be pushed off. The broad band which binds the tip of the left lobe of the liver close to the foramen œsophagæum of the diaphragm was then divided in order to be able to push the liver lobe more to the right. But little room was gained thereby. The stomach was now surrounded by the two forefingers, distal to the lower border of the tumor, and turned upward around its longitudinal axis for almost 180°, thus permitting ligation and division of omentum minus beyond its infiltrated glands; left superior gastric artery was caught in the last mass ligature (Fig. 11). Technically, this work was not easy; it had to be carried out in a sort of funnel, because the costal arch did not sufficiently yield to the assistant's traction with a large blunt hook, and I had made up my mind to avoid osteoplastic resection of the arch. Followed: gradual, blunt loosening of cardiac tumor, which was not difficult. Tumor infiltration ran up on the œsophagus for fully one and a half inch. On pulling the mass downward, the thoracic portion of the œsophagus descended only a trifle, surely not the way Voelcker and Kuemmell had seen it in their cases, although all adhesions around the cardia had been severed as much as possible. Firm adhesions around œsophagus in posterior mediastinum were palpated further up. Transverse double line of sutures of stomach

[13] See Centralbl. f. Chir., 1901, No. 42.

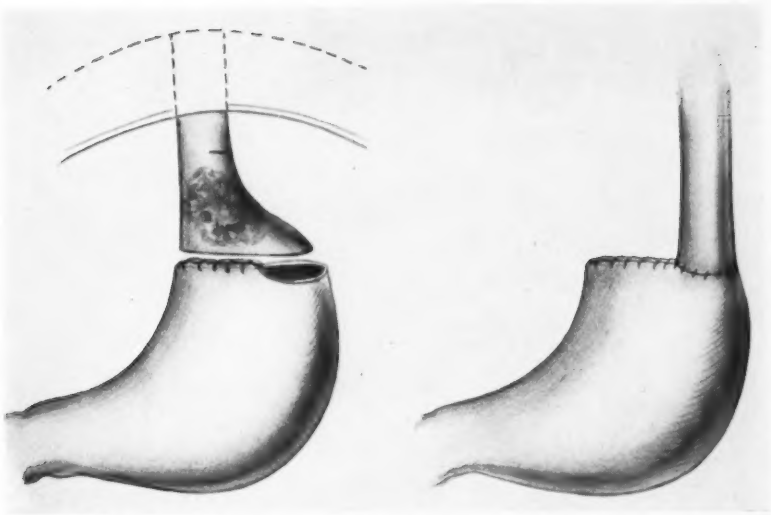

FIG. 1.—First successful case of resection of the cardia for carcinoma. (Voelcker, Heidelberg, 1908. Diagram drawn by writer.) Removal of tumor entirely from below, through the abdomen. Immediate end-to-end union by Billroth's method No. 1. Tamponade; temporary leakage; recovery.

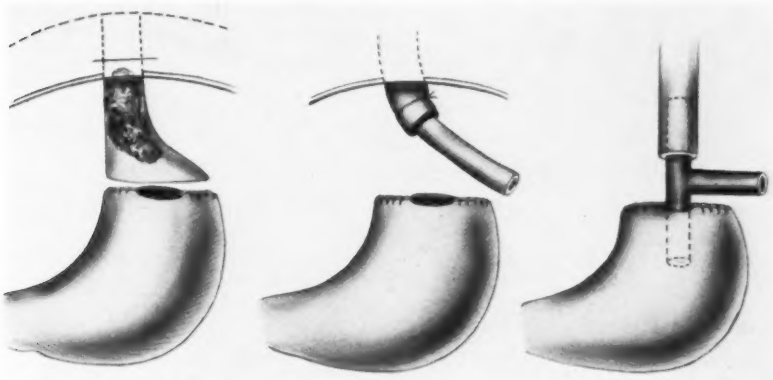

FIG. 2.—Second successful case of resection of the cardia for carcinoma. (Kümmell, Hamburg, 1910. Diagram drawn by writer.) In this case, too, the operation could be done entirely within the abdomen; pleural sacs were not interfered with, as cardia, after being loosened, could be pulled down for a distance of 10–12 cm. Immediate union impossible, as distance between resected parts was too long; tube tied in œsophagus; gastrostomy; subdiaphragmatic tamponade; later T-tube; gradual closure.

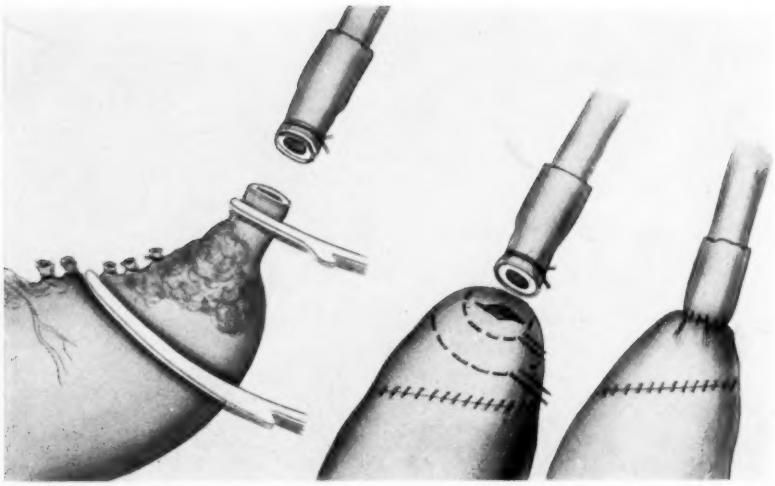

FIG. 3.—Third successful case of resection of the cardia for carcinoma; operative recovery (Sauerbruch, Zurich, 1910). Transpleural operation under differential pressure; growth loosened from above; excision of tumor; closure of stomach; latter pulled up above diaphragm into thoracic cavity and anastomosis carried out with Tiegel's button. Operative recovery; pneumonia on fourteenth day; exitus. (Illustration from Sauerbruch und Schumacher, *Technik der Thoraxchirurgie*, p. 91.)

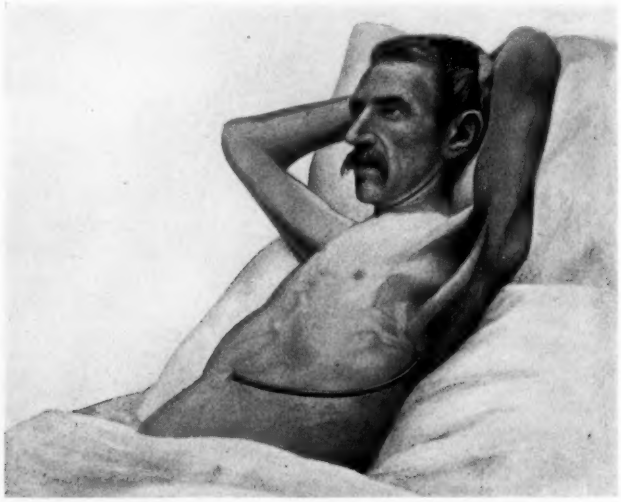

FIG. 4.—Fourth successful case of resection of the cardia for carcinoma (*Zaaijer, Leiden*, 1912). After gastrostomy and resection of lower ribs in first and second stages, combined thoracotomy and abdominal section; excision of tumor; proximal stump left *in situ*, its lower end brought out in axillary line; patient well able to swallow after introduction of rubber tube. (Illustration from Zaaijer's article, l.c.; rubber tube added to it by writer.)

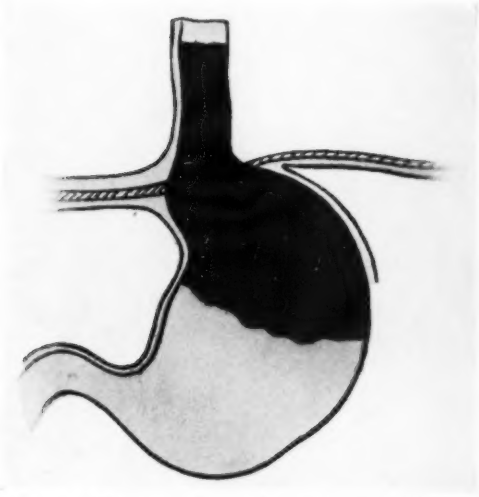

FIG. 5.—Fifth case of resection of the cardia for carcinoma; operative recovery (Ach, Munich; 1912). The blackened part in the diagram represents extent of tumor. Excision done from abdomen; extraction of proximal stump of divided œsophagus by special method; gastrostostomy added. Eleven days later beginning insufficiency of gastric fistula, to which patient succumbed on seventeenth day after operation. (Illustration from *Ach, Beitraege Z. (Esoph., Chirurgie*, p. 72.)

FIG. 6.—Gastrotomy with the help of an osteoplastic resection of the costal arch in the presence of a gastric fistula, by means of a V-shaped incision, for impermeable cicatricial stricture of the œsophagus (author). Recovery from operation (see *Journal of American Medical Association*, October 6, 1906).

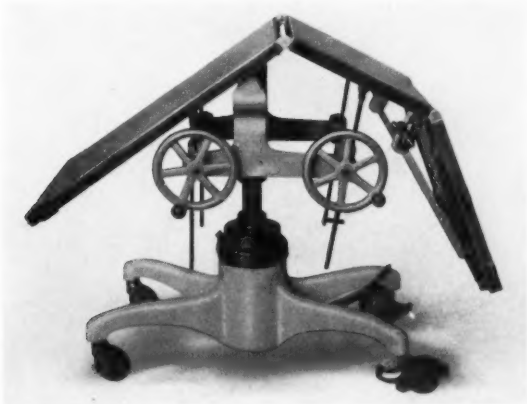

FIG. 7.—Operating table of latest type, permitting of pronounced lordosis.

FIG. 8.—The same, patient in position for operation.

FIG. 9.—Kelling's posture for infradiaphragmatic work, with patient's feet hanging down perpendicularly, the upper half of the body alone remaining on the operating table. This posture gives excellent access.

FIG. 10.—Oblique abdominal incision in presence of gastric fistula. The artist has left the tube in place for demonstration. For the operation the tube had, of course, been removed and the fistula plugged with iodoform gauze and covered with sterilized adhesive plaster, which in addition had been painted with tincture of iodine.

FIG. 11.—Omentum majus and minus doubly ligated and cut; the last ligature of the latter includes left superior gastric artery; stomach divided; distal end sutured; proximal clamped. In the case reported the transverse cut of the stomach was accomplished with Hueltl's wire stitching instrument, the distal part of the stomach being at once inverted and secured by a running silk suture.

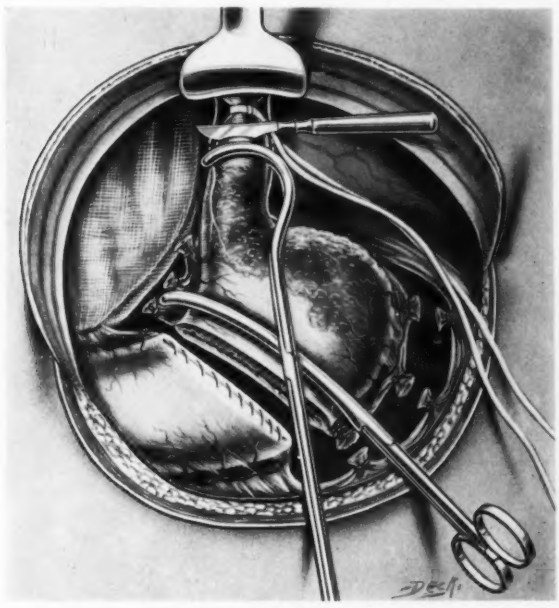

FIG. 12.—Liver covered with gauze sponge; tumor loosened in foramen œsophagæum, its upper end clamped with curved forceps; the proximal portion of the œsophagus, about one inch above, tied off with a piece of narrow tape, the ends of which are left long. Nervi vagi divided; knife ready to cut through the œsophagus. A blunt hook placed in the posterior mediastinum facilitates access.

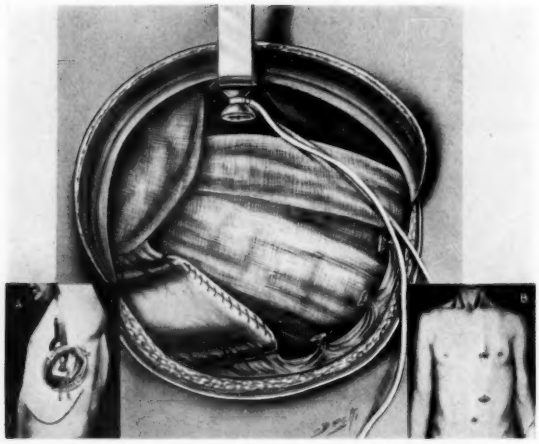

FIG. 13.—Tumor removed; operating field within abdomen covered with gauze; the tape, left long after ligation, hangs out of the wound. *A*. Shows additional thoracotomy and the result of procedure which became necessary in order to place the proximal œsophageal stump in front of the aortic arch, before extraction from the neck could be done. *B*. Operation finished; œsophagus transplanted subcutaneously under the left side of the chest.

FIG. 14.—Specimen removed from Case I. Photograph taken six months after operation. Specimen kept in formalin (natural size).

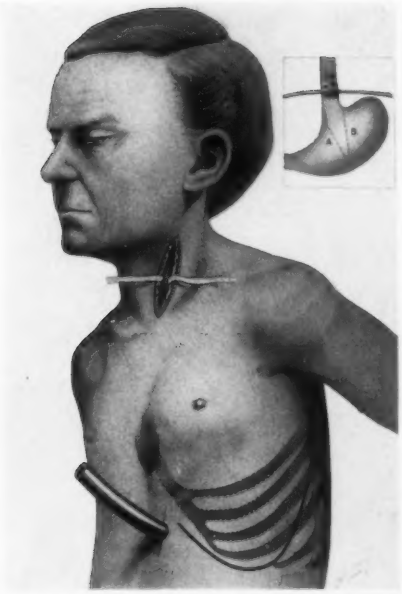

FIG. 15.—Diagrammatic: Oblique abdominal incision in presence of gastric fistula. (Tube is again shown in place by the artist, although it was removed and the canal plugged and sealed before the second operation.) The dark, short, straight lines show where, in front, the broad rib cartilage and where the eighth, ninth and tenth ribs were divided in the axillary line. The small picture, also diagrammatic, illustrates the inadvertent division of the stomach toward the outside of the cardia (*B*), instead of to the inside of the same (*A*), as intended.

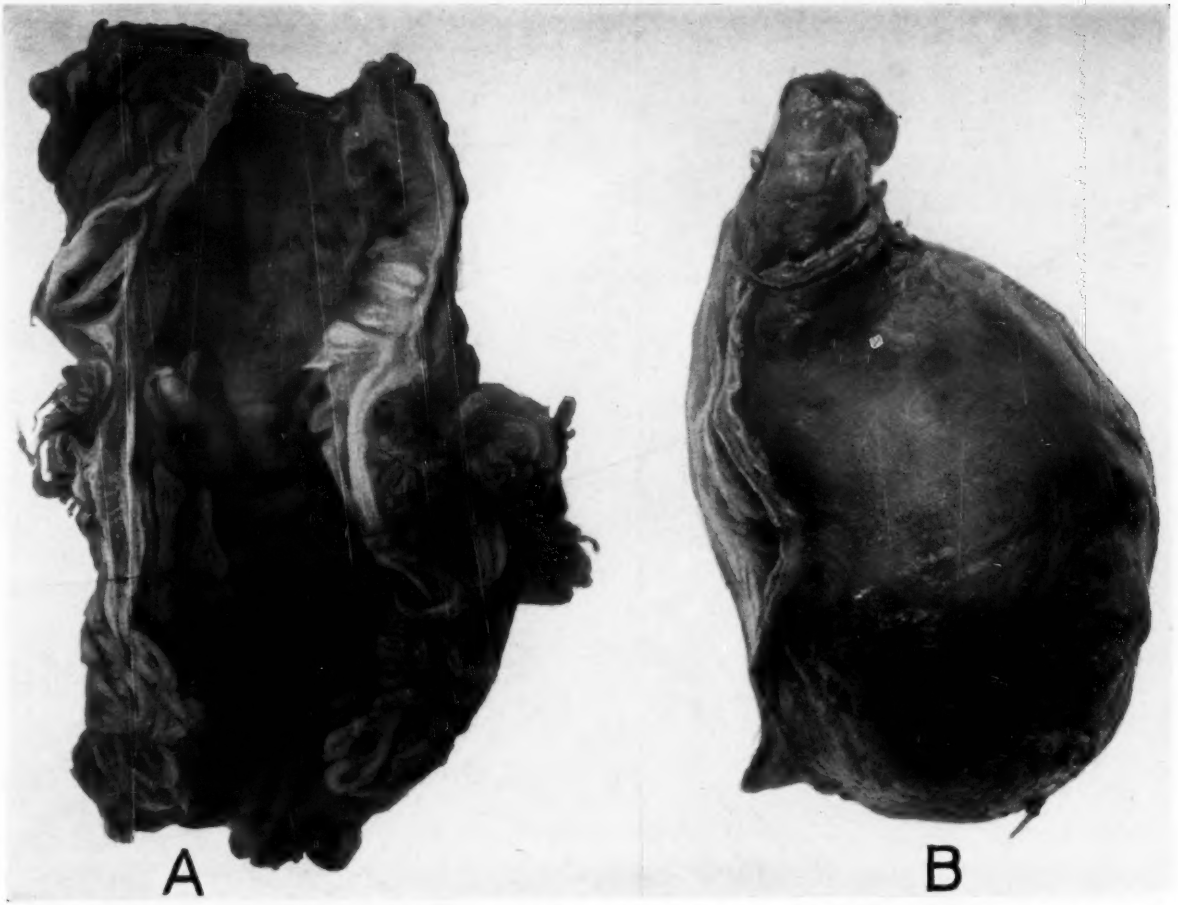

FIG. 16.—Specimen (*A*) removed from second patient operated on; *B* shows the cardiac pouch which had been cut off inadvertently (natural size).

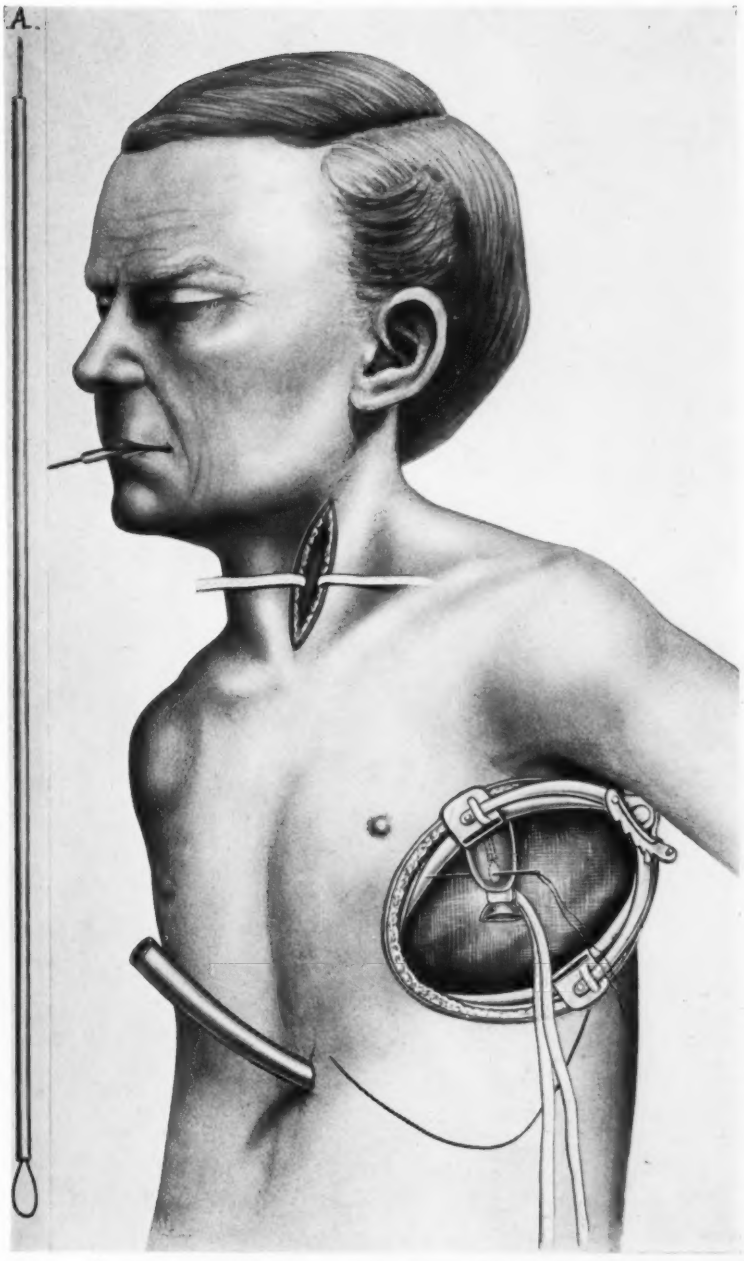

FIG. 17.—Thoracotomy added to laparotomy; rib spreader in place; needle with linen thread pierces the loop of the wire, introduced by the narcotizer down to the point of ligation of the œsophagus. Abdominal incision outlined. Sound at left.

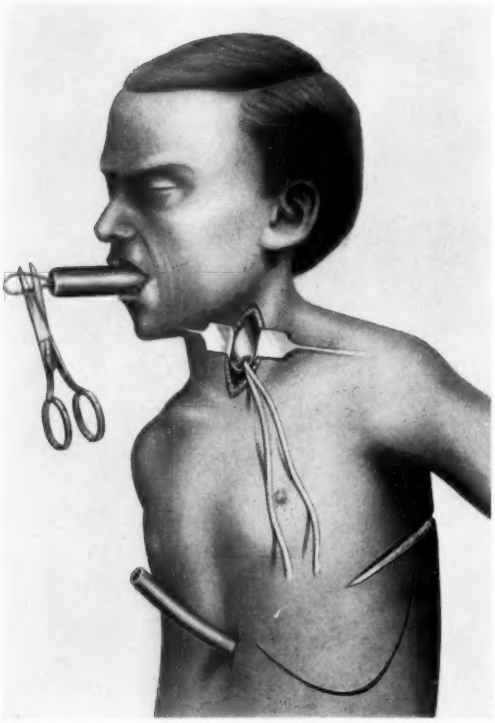

FIG. 18.—Œsophagus everted, extracted from the mouth of the patient by the narcotizer, until the tape, pulled up in the posterior mediastinum, appears at level of the neck wound which is held apart by blunt retractors. The long ends of the piece of ligating tape are lifted out of the neck wound and placed on the chest. The thread in front of the mouth is divided with scissors by the narcotizer. Abdominal and thoracic wounds outlined.

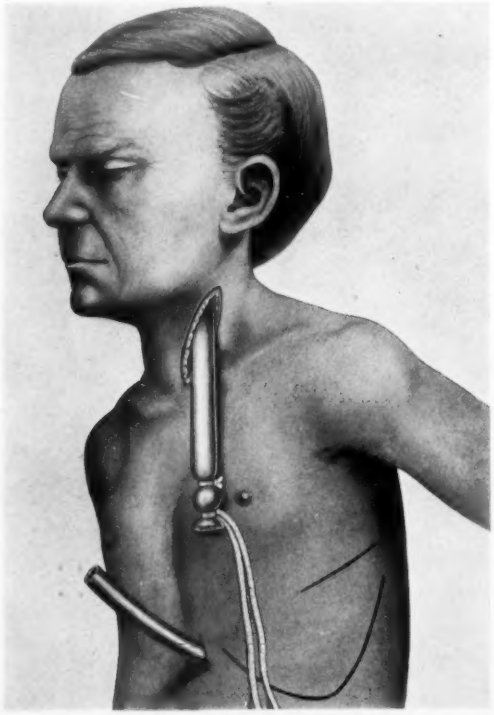

FIG. 19.—The surgeon has, by a gentle pull on the long ligature ends, re-everted the œsophagus which now hangs down on the chest wall. Abdominal and thoracic wounds outlined.

FIG. 20.—Proximal stump placed under the skin tunnel of the chest; lower end opened, stitched in place; rubber tube shown, as it would have connected the lumen of the œsophageal stump with the gastric fistula (Gluck-Perthes method).

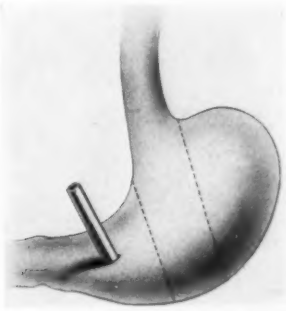

FIG. 21.—Diagrammatic: Emergency operation suggested by the accident that occurred. By running a second line of transverse division on the other side of the œsophagus, the latter could have been quickly lengthened by a piece corresponding to the transverse diameter of the stomach, the closed major curvature being stitched in the abdominal wound, to be opened forty-eight hours later. Of course, the entire cardiac pouch of the stomach is to be used and a short distance of the same sutured in the abdominal wound, if the surgeon has to break off the operation at this juncture.

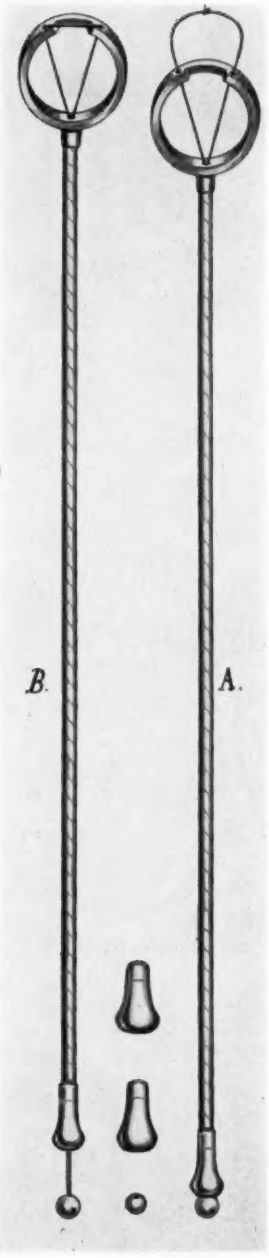

FIG. 22.—Author's œsophageal extractor, rendering the extraction an absolutely aseptic procedure. *A*, ready for introduction: the perforated bullet is drawn up toward the sound's mushroom tip, which has a rounded border. *B*, the bullet is milked down until it approaches the ligated stump of the proximal end. Above it a tight ligature is then placed (see Fig. 18 and 23 *D* and *E*). The separation of shot and mushroom can also be obtained by holding the shot and having the narcotizer pull the sound back.

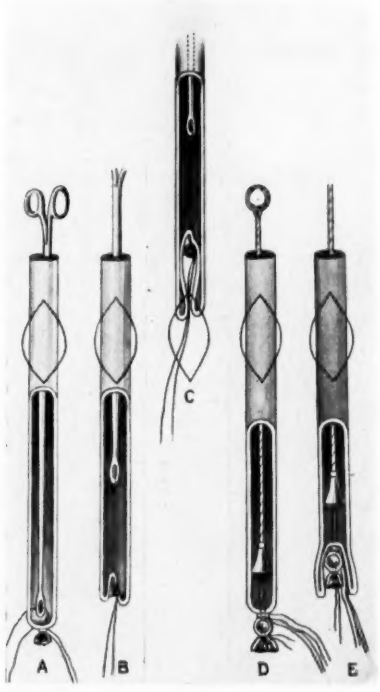

FIG. 23.—Diagrammatic: Showing œsophagus stump in course of extraction, *A*, *B*, and *C* being done with Ach's wire extractor (taken from Ach's book); *D* and *E* demonstrating the procedure with the author's extractor. The oval represents the neck-wound which exposes the œsophagus. In *D* and *E* the silk threads are shown by the artist to pierce the wall of the œsophagus, the lower end of which harbors the perforated shot. Of course, they pass to the shot through the lumen of the œsophagus and do not pierce the œsophageal wall.

placed at its middle by means of Hueltl's large wire stitching instrument.[14] A good-sized pouch was left in connection with the gastric fistula. Division of stomach between the suture lines; inversion of the distal end by a running silk suture; straight clamp on proximal end of stomach. Both pneumogastric nerves at and above cardia clearly visible; they were tightly attached to and surrounded by the tumor. They were freed and cut through; curved clamp placed on œsophagus right above tumor; it furnished an additional good tractor. Crushing and ligation of the œsophagus with narrow tape further up, and division of the tube between (Fig. 12). This step finished the complete removal of the cardiac carcinoma (Fig. 13). Sterilization of œsophageal stump with pure carbolic and alcohol. Had I had Ach's wire with endloop (Fig. 17 *A*) at hand, I might likely just have been able, by means of strong downward traction of the tumor while it was still in its normal anatomical relation to the cardiac portion of the stomach, to reach the healthy part of the œsophagus from below and pierce the loop on the lower end of the wire which is introduced into the closed œsophagus by the narcotizer, with a straight needle and silk thread (*cf.* CASE II). I might also have been able to extract the proximal stump in spite of the still present adhesions. But not having such a wire at hand, and the patient's condition at this time still being good, I had him turned entirely on his right side and added left thoracotomy in the seventh interspace (Fig. 13 *A*). After placing the rib-spreader and after incision of the mediastinal pleura to the right of the descending aorta the œsophageal stump was immediately found and thoroughly freed. I now had hoped to be able to extract the œsophagus without special difficulty through the œsophagotomy wound in the neck which had to be added, as I had been able to do in previous operations. But this time, unfortunately, the œsophagus did not yield; it had gradually to be freed intrathoracically and first extracted from behind of and placed in front of the aortic arch (Fig. 13 *A*), a difficult and time-consuming procedure through a straight intercostal incision without additional posterior division of ribs upward. The field was away up and difficult of access. But an additional bone operation I wanted to avoid at all hazards in order to reduce the severity of the complicated work. And yet it might have been better for patient and operator had I quickly added a posterior cut upward and divided three or four ribs at their angle (Torek's incision). After the œsophagus had been brought in front of the aortic arch it yielded to the pull of the forefinger which had been put around

[14] See Jour. Amer. Med. Assn., January 10, 1914, pp. 100–105.

it in the neck wound. It was found that the mass ligature of narrow tape, which closed the lower end, had slipped off during this manipulation, spoiling the asepsis. Clinical observation must decide whether transverse perforation of the œsophagus with needle and thread (silk or linen), and using the latter for *safe* closure, viz., without the possibility of slipping off, and prompt, thorough iodinization of this ligature, will disturb asepsis. If not, it will be *the* method of tying the œsophagus. The extracted œsophageal stump was now placed, as usual, under an antethoracic skin bridge and stitched in the transverse wound right above the third costal cartilage (Fig. 13 *B*), the still tied end projecting for a short distance. Now the wounds in the neck, thorax and abdomen were closed by layer sutures, the pleural cavity having been drained through an incision in the ninth interspace [15] and dressings applied. The patient was placed under differential pressure for after-treatment, with his head in the positive cabinet which had recently been installed in the room for thoracic surgery at the Post-Graduate Hospital.

As was to be expected, the patient was in a state of profound shock, though his pulse was 108 after an intravenous infusion which had been given in the course of the latter part of the operation. Despite the use of all possible stimulants he died fifteen hours after the operation. No autopsy. Microscopic examination of the tumor (Fig. 14) proved it to be an epidermoid (squamous-celled) carcinoma.

CASE II.—In the second case I planned to follow Ach's method more closely and therefore procured the wire with the endloop (Fig. 17 *A*). Male, aged fifty-two years; patient of Dr. G. S. King, of Bayshore, L. I., who kindly referred him to me. Strong man, still weighs 200 pounds, having lost more than 30 pounds during the last few months; fluid food only passed down during the last three weeks. February 5, 1915: Callman's sound meets impassable stricture 38 cm. from incisor teeth. Olive tip finds resistance at 40 cm.[16] X-rays demonstrate distinct stricture near

[15] So far I have drained such thoracic cases in whom I considered drainage the best procedure for the patient on general surgical principles by retaining the patient under differential pressure at the close of the operation. (See ANNALS OF SURGERY, July, 1912.) Of course, the problem of effective drainage after a thoracotomy, which involves the avoidance of a post-operative acute pneumothorax, may be solved in many ways without the use of cabinet or chamber. (*Cf.* Tiegel, Langenbeck's Archiv. f. klin. Chir., vol. xciii, p. 311, and Kenyon's method. Johnson: Oper. Therapeusis, vol. i, p. 242.)

[16] The obstruction, made out by a sound, means the point of greatest contraction in the course of a malignant stricture, not its upper end, while the tumor may cover quite some length of the tube.

cardia. Œsophagoscopy (Dr. Yankauer). February 11, Witzel's gastrostomy, at German Hospital. Palpation shows a hard movable tumor above cardia in region of œsophageal hiatus; cardia not involved; enlarged glands in lesser omentum; stomach small. Forced nourishment, with full diet, properly chewed and deposited in warm fluid and injected into stomach with large hand syringe through gastric tube.

In view of the obstruction having been made out 38 cm. down, which meant that it might be impossible to reach the healthy portion of the œsophagus by way of the abdomen, it was proposed to the family that the operation be done in three stages, viz.: Stage 2: thoracotomy; division of œsophagus sufficiently above tumor to insure safe inversion of tied distal end, antethoracic transposition of proximal stump; thoracic drainage. Stage 3: removal of tumor from an abdominal incision after transverse division of stomach. The family was rather opposed to such division of the work, clearly indicated as it seemed to me, and they pleaded for a final second stage. I yielded to their wishes, hoping that I yet might be able to extract the œsophagus according to Ach, working from the side of the abdomen only.

Radical operation (March 18).—First assistant, Dr. Rehling; intratracheal insufflation (Dr. Sanford). Patient bears this kind of anæsthesia very poorly; large amount of anæsthetic required before reflexes cease; persistent cyanosis in spite of carrying out insufflation properly in every detail. Preparation of patient as above described; incision at neck; œsophagus loosened and surrounded with tape; loose tamponade. Abdominal incision as in Case I. Parts not well accessible. Increasing lordosis makes little difference. Therefore additional division of left seventh costal cartilage near sternum, and eighth, ninth and tenth ribs in axillary line (Fig. 15). With a costal arch—rib flap thus formed and pulled up, good access is obtained. Circumcision of foramen œsophagæum, dividing diaphragmatic peritoneum and—bluntly advancing—freeing œsophagus all around; adhesions posteriorly very tight. On traction downward the œsophagus yielded but very little. The finger found œsophageal infiltration away up as far as it could reach, making it plain at once, much to my dismay, that thoracotomy would again have to be added in the same sitting, as in Case I. Gradual mass ligature of either omentum; there was a broad posterior adhesion of the stomach, which made work rather difficult; cardia surrounded and lifted up with a piece of tape.

On dividing the stomach, which had an unusually distended cardiac pouch, with Hueltl's large wire-stitching instrument, a

peculiar accident occurred, which, I feel, I ought to mention. A transverse division of the stomach, not far to the right from the cardia, which as such was found healthy, had been prepared for. The instrument was properly placed in position, then closed and clamped as usual, while the second assistant supported the cardia with the tape loop and the first assistant took hold of the end of the instrument within the abdomen. After cranking and opening it under the costal arch, it was found that the cardia, evidently at the last moment, had been inadvertently withdrawn from the grasp of the instrument, most likely by an unintended pull upon the tape held by the second assistant, who could not see the field of operation. This is possible, as "the Hueltl" has one single big blade, more than one inch wide, which, after closure, takes hold of the intestine, crushing the centre of the part it has in its grip.[17] Thus the upper end of line of stomach division passed the cardia close to its left instead of its right side (Fig. 15, small picture, line *B*), cutting off the stomach pouch lying to the left of the cardia (see Fig. 16 *B*). A second division of the stomach nearer to the pylorus had therefore to be done (Fig. 15, small picture, line *A*), and all three lines of incision closed with needle and thread, a rather irksome procedure. Tumor, with the closed stomach pouch attached, was now pushed through foramen œsophagæum into the posterior mediastinum above the diaphragm and a gauze tampon inserted on top to keep it there. Four temporary sutures in wound of abdominal wall. Lateral posture increased. Thoracotomy in seventh intercostal; lung nowhere adherent. Mediastinal pleura incised near aorta; pleural wound bluntly enlarged; tumor dissected and lifted up with attached stomach pouch; it was wrapped in gauze. Adherent pneumogastric nerves divided. Œsophagus crushed and tied within healthy tissue with a piece of narrow tape which was left rather long (Fig. 17); curved clamp placed distally; division of œsophagus with knife, therewith excising the tumor of the cardia (Fig. 16); disinfection of the stump with carbolic acid and alcohol. Introduction of wire loop (Fig. 17 *A* and Fig. 23 *A*), by narcotizer (the same can be well felt by the surgeon's fingers); piercing of loop with needle and thread (Fig. 17), which latter is left about 4 to 5 inches long; ends knotted. Extraction of œsophagus (Fig. 23 *B*); method works admirably. It is seen that tube is nicely inverted (Fig. 23 *C*). As soon as the tapes appear in the neck wound which was held well apart (Fig. 18), the narcotizer cut the silk thread in front of the inverted œsophagus (mucosa outward), the lower end of which naturally had ap-

[17] See Jour. Amer. Med. Assn., 1914.

peared in front of the mouth. With gentle pull on the thread in the neck wound, it was easily re-everted and slipped downward on the chest (Fig. 19). The whole procedure impressed me and everyone present as a most useful, gentle and ingenious method of transposition of the oral stump of the œsophagus, no matter how long. Transverse skin incision over third intercostal space near sternum; skin tunnelled and œsophagus placed subcutaneously (Fig. 20), tip being left unopened, somewhat projecting. Layer suture of neck and thoracic wound; drainage of pleural cavity; suture of foramen œsophagæum and diaphragmatic peritoneum from below, and of abdominal wound. While we were busy with the latter work, the narcotizer reported inability to make out patient's pulse; strong stimulation; operation completed. When insufflation was stopped, there was no spontaneous respiration nor heart-beat. Insufflation had kept the lungs distended and collapsed, but the centres in the medulla had died and could not be resuscitated.

I believe that the difficulty experienced with insufflation—the patient remained cyanotic throughout the operation—had something to do with the fatal issue at the end of the work. In future I shall stop operating and continue at a later date, if proper ventilation of the lungs cannot be established. Of course, it may be a difficult matter for the surgeon to discontinue in the course of an operation of this kind.

This case teaches that the operation should be a three-stage one, if the cancerous infiltration is likely to involve a greater portion of the intrathoracic tube, so that the healthy part of the œsophagus cannot be safely reached from below. The extensive invasion of the abdominal plus thoracic cavity at the same sitting is clearly too much for these weakened individuals. But, I believe, *the aim* must be in resection of the cardia for carcinoma, to extract the œsophagus according to Ach, avoiding a transpleural thoracotomy, and thus get through with the extirpation of the growth *in one sitting*.

On pondering over the accident recorded above and illustrated in Fig. 15 (small picture), I regret that I did not break off the operation right at that point. Had I at this moment decided to do a three-stage operation and at once made a second transverse incision through the stomach to the right of the cardia, the œsophagus would have been lengthened by a continuous organic tube corresponding to the transverse diameter of the stomach (Fig. 21). The lower end of this new tube, represented by the major curvature, could have been stitched in the abdominal wound, slightly projecting, and opened after forty-eight or sixty hours, the patient being meanwhile fed through the gastric fistula.

When removing the tumor radically in the third stage, the part could then have been easily dissected from the abdominal wall, the opening inverted and the mass excised in an aseptic manner. This is said under the assumption that the arterial blood passing from the œsophagus past the tumor on to the stomach would have sufficed to nourish the artificial organic extension of the œsophagus. It will be remembered that both omenta with the main arteries for the cardiac portion of the stomach had been tied off primarily in order to mobilize the lower end of the œsophagus, which proved to be a difficult proposition without such ligation on account of lack of room, a trouble which seemed to depend mainly on the presence of the gastric fistula. To meet emergencies in the course of resection of the cardia it certainly seems best to follow Ach and ligate the omenta *after* the division and extraction of the œsophagus, provided this is technically feasible.

An objectionable feature of the way Ach goes about the extraction is: Piercing of the œsophagus with needle and thread and pulling on the thin wall of the œsophagus by means of the latter. In the case reported I have seen a tear, one-eighth of an inch in length, of the wall of the œsophagus, made by the thread. Piercing the œsophagus may, furthermore, hurt asepsis. Ach believes he can avoid infection by starting the extraction the moment the penetrating thread has been tied. But does this really avoid it? Better, certainly, had the œsophagus been left intact.

From these considerations has the extractor been conceived which is shown in Fig. 22, and the process of extraction in Figs. 23, *D* and *E*. This extractor consists of a somewhat modified Callman sound and a heavy piece of shot, perforated and suspended, like a bead, on a silk thread, which is passed through the hollow stem of the sound. The suggestion to place the thread within the stem came from Dr. S. Yankauer, to whom I showed my sketches after I had discussed them before the Clinical Society of the German Hospital, on April 9, 1915. The doctor also kindly directed for me the manufacture of the first instrument.

The extractor is introduced with the shot pulled up snugly against the mushroom (Fig. 22, *A*) and is pushed forward to within a few inches of the ligature, closing the oral stump. The shot, which can be clearly felt through the wall of the œsophagus, is then milked down close to the ligature (Fig. 22, *B*). The œsophagus is next ligated between shot and mushroom by means of a tight tape-ligature (Fig. 23, *D*) and now extraction begun (Fig. 23, *E*), the mushroom opening the way for the ligated end of the stump and the pull being on the shot and the

taped œsophagus. (In the illustration the œsophagus above the mushroom should have been shown collapsed.)

I have tried the instrument in a dog, where it worked very well. There is no reason why it should not work equally well in the human subject. In case of emergency, an ordinary œsophageal sound with olive tip might, of course, be used.

Reviewing the technical aspect of resection of cancer of the cardia, or, in fact, of cancer of any other part of the œsophagus, it seems to me that the present status holds out well-grounded hope for the possibility of doing more frequently successful work, than has been seen so far.

A further point, essential for a more frequent successful issue of resection of the cardia, is early diagnosis.[19] The fulfillment of this requirement lies to a great extent in the hands of the general practitioner who usually sees these patients first. Knowing the mortality of expectant treatment to be 100 per cent. and almost as high following operation when delayed too long, he must learn to consider a patient who complains of difficulty in swallowing *a surgical case,* just as he now regards acute appendicitis as a clearly surgical trouble. Of course, the blame for the unfortunate delay does not always rest with the general practitioner. Not infrequently the patient does not call for medical advice until months after the onset of the trouble. Still, the ever-recurring and increasing obstruction to normal swallowing usually worries him, and in the majority of cases he will ask for medical aid at a time when the surgeon could still bring real help by a radical extirpation.

It is conceivable that a certain percentage of very early cases of cancer of the œsophagus or cardia could be benefited by intra-œsophageal treatment with radium. The majority of these tumors are of the squamous-celled type, which corresponds to the epithelioma of the skin, a disease which in many instances yields so beautifully to radium. And this is a clinical fact of which I could personally satisfy myself in quite a number of my patients. Of course, the œsophagoscope must corroborate the local change for the better, if gradual improvement of the obstruction to swallowing should point to an effectual result of the radium treatment. For it must not be forgotten, that improvement in the act of swallowing is frequently observed in these patients when nothing at all was done. It certainly will be of importance to have some of these cases submitted to radium rays at the hands of experts, and to have their clinical findings carefully recorded and final results demonstrated.

[19] See author, "The Early Diagnosis of Cancer of the Œsophagus," Amer. Jour. Surg., July, 1915.

Personally, I fear that a *radical cure* will be achieved in very few cases, if at all, and that by such attempts the best time for operation will be lost. Furthermore, the possibility of a perforation by a radium burn must be considered. So far no case has been recorded in which an œsophageal malignant tumor was *permanently* benefited by radium. Until such positive results can be shown it remains, of course, our solemn duty, to consider *all* these patients *operative cases,* and that at as early a date as possible. The cylinder-celled carcinoma which takes its origin from the epithelial cells of the mucous glands of the œsophagus and often involves several inches of the tube will most likely not yield to radium, and therefore remain permanently and wholly under the domain of operative surgery. Dr. M. Einhorn, of New York, was the first to write on this subject years ago (*N. Y. Med. Record,* March, 1904, and *Journ. A. M. A.,* July, 1905). At present a number of American colleagues are at work in the same direction. It would be most gratifying if they succeeded.

Let us all, then, in word and print, again and again, emphasize the importance of the dictum: A patient with difficulty in swallowing that came on gradually, without apparent cause (burn, etc.) needs a strict diagnosis at once. This is best done in a modern, well-equipped hospital. If suspicion of malignancy exists, the case is to be considered a surgical one immediately.

Of course a large number of doubtful points remain to be cleared up, some of which may take many years for their definite solution. I will mention here only a few.

Is primary gastrostomy as the first stage absolutely necessary? Could the gastric fistula not be established after the excision of the tumor at the same sitting, viz., the entire work be done at one stage? A series of animal experiments in which thoracotomy with division of both pneumogastrics plus gastrostomy were done at the same sitting, might help to solve this question. In other words, it remains to be shown whether primary double division of the pneumogastrics within the thorax or at the cardia really is the cause of leakage of the gastric fistula (observation by Ach and by author, each one case).

Can we get sufficient access to the vault of the diaphragm without an additional bone operation, in the presence of a gastric fistula? It has seemed to me in the course of the second operation, that the division of a fascia band, near the tip of the eleventh rib, suddenly gave much better room. Special attention should be paid to this point. It is possible that similar fascia conditions exist in front, as W. J. Mayo found in his incision for operations on the kidney below the twelfth rib.

How long may be the transposed proximal stump of the œsophagus without becoming necrotic? By what means can we prevent necrosis at the distal end?

Should, for the purpose of extraction, the nervi vagi better be dissected off the œsophageal wall and left intact, like guides on either side of the tube? It is plausible that in the presence of firm adhesions alongside the œsophagus one of the nerves might be torn out if divided near the cardia before the extraction.

In view of the fact that excision of the malignant tumor is the main object of the work, is it wise or permissible to make it the third stage of the operation?

What we must not forget, is, that we are only just entering upon this new field of operative surgery. However, a start has been made, and the right start at that, it seems. The sooner the work is more generally taken up, the more rapid will be its advance.

Let us then remember that we have to-day at our command not only the mechanical means enabling us to combat the present difficulties and dangers of the operation, but also a proper plan of procedure. Let us remember, also, that the possibility of early diagnosis of cancer of the œsophagus promises to be soon an established fact in the hands of experienced specialists. It has been shown that successful excision of cancer of the cardia is possible. Hence we no longer have the right to declare a patient inoperable simply because his tumor happens to have developed at the cardiac instead of the pyloric portion of the stomach, thus condemning him to a slow death, connected with untold suffering.

In other words, we must bear in mind that it is not the location of the tumor that decides its operability or inoperability, but the actual pathologic condition in the vault of the diaphragm. And this can be determined only by the palpating hand of the surgeon.

OBTURATOR HERNIA

WITH REPORT OF CASE

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Mumford states that about 200 cases of obturator hernia have been reported in surgical literature.

Meyer, reporting 6 cases from the Leipzig clinic, states that 51 cases had been previously reported since 1875.

Grasser has compiled statistics covering 118 cases in a period extending from 1720 to 1890.

In view of these facts, we venture to report our case, trusting that the condition is rare enough to justify reporting.

Occurrence.—The greater number of reported cases have occurred in elderly females. Seventy-nine per cent. of Meyer's cases occurred in women over 60 years of age and the statistics of other authors agree with his.

Most of the cases give histories of considerable emaciation following obesity.

Meyer has drawn some conclusions regarding the etiology of obturator hernia from these facts. They are as follows:

First, obturator opening relatively larger in women than in men.

Second, frequent pregnancies cause laxity and folding of the peritoneum, which may project through the opening.

Third, emaciation removes the normal cushion of fat and renders the opening more easily penetrable.

Fourth, subserous lipomata, which often coexist with this form of hernia, may be responsible for the origin in some cases. He adds that views concerning the origin of obturator hernia have never been uniform.

Types.—Lejar described three types of this condition:

1. Type traversing the entire length of the obturator canal from behind forward emerges from the anterior orifice and spreads out in front of the external obturator muscle and under the pectineus.

2. Emerges between the upper and middle fasciculi of the external obturator muscle and becomes encircled and constricted by double muscular band.

3. Hernial sac burrows from above downward between the two layers of the obturator membrane and remains entirely behind the external obturator muscle. On opening the pectineus, no hernia presents itself and a second muscular plane must be incised before the sac is found. Other difficulties are caused by the inconstant relationship of the obturator artery and its branches to the neck of the sac.

Diagnosis.—Diagnosis is extremely difficult. Mumford states that operation has never been performed up to the present time except for strangulation.

1. With the pelvis elevated and the thigh flexed and moderately abducted, the hernia may occasionally be recognized as a prominent swelling in the upper part of the adductor region to the inner side of the femoral vessels. Often, however, the swelling is small and little apparent and only a diffuse asymmetry can be discerned.

2. Localized pain may be elicited by pressure at the inner part of Scarpa's triangle near the pubic spine. If the pain radiates definitely down the inner side of the limb to the knee, the diagnostic value will be increased. This is called Romberg's sign and is due to compression of the obturator nerve. It is rarely absent.

3. The entrance to the obturator canal is accessible to vaginal palpation in the female and localized pain or a characteristic swelling or tense band may sometimes be recognized by this means.

This may also be demonstrated by rectal examination in the male.

Meyer very sensibly remarks that diagnosis, at best, is only a probable one and that operation should therefore be early.

Operation.—Lejar advocates the following procedure:

First, pelvis raised by thick pillow or sand bag, thigh flexed and moderately abducted, recognize femoral artery and make 5-inch vertical incision one and one-half inches inside of it, beginning one inch below pubic spine.

Second, incise skin, subcutaneous tissue and deep fascia. Avoid the internal saphenous vein or divide it between ligatures. Recognize fibres of adductor longus running obliquely downward and outward and fibres of pectineus along its outer border. Protect great vessels with large retractor and open space between adductor longus and pectineus with grooved director or finger. As the pectineus covers the obturator opening it must be freed and retracted sufficiently to give good exposure. If necessary, a transverse incision may be made in its fibres or it may be detached partially from the horizontal ramus of the pubis in cases where access is difficult.

Third, herniæ of the ordinary type will now be plainly visible and

the sac may be isolated up to its point of emergence. In type two carefully divide the upper portion of the muscular band.

In type three the hernia will be beneath the obturator muscle and this must be freely opened by separation in line of fibres or free division.

Fourth, after freeing sac, open by a careful incision, making sure by palpation and inspection that no aberrant artery runs over the anterior surface. Try to free neck by stretching downward and inward with tip of index finger. In case this cannot be done bear in mind the following facts:

(*a*) Constriction is always due to edge of obturator membrane external to sac.

(*b*) Draw sac aside, seek extravascular zone by palpation, or make sure of position of obturator artery and branches. Make two or three very cautious nicks under direct inspection and complete by stretching with finger. In case the neck is surrounded by a complete arterial ring make incision between two pairs of hæmostats applied high as possible.

Fifth, extract, inspect and, if necessary, repair herniated bowel.

Ligate sac and, if possible, close anterior orifice of canal by a few sutures.

Lejar strongly emphasizes the dangers due to the vascular relations in these cases. While in the ordinary type of hernia the artery and nerve are usually behind the neck of the sac and a little to its outer side, the artery has been found on all sides of the sac and the neck has been found surrounded by a complete arterial circle. Consequently, the freest possible access should be provided, the neck of the sac clearly exposed, the position of the neighboring arterial branches ascertained by inspection and palpation, and ample room provided for adequately dealing with hemorrhage in case a large vessel should be wounded in spite of all care. He also mentions the abdominal operation, saying that it usually permits of more easy reduction and avoids the vascular dangers. However, he says that extreme caution is necessary to prevent peritonitis from septic sac contents. While the sac cannot be excised by the abdominal route the neck can be closed by a few sutures.

Meyer advocates the abdominal operation, citing the following advantages:

1. Better view of field of operation.
2. Reduction facilitated.
3. Intestinal resection can readily be performed, if necessary.

Mumford suggests the advisability of opening the abdomen from above after isolating the sac and freeing the neck. This would give advantage in making any necessary repairs on the bowel and would also permit of ligation and removal of the sac. He says results have been unfavorable in this operation because of the difficulty in adequately treating the herniated bowel through the obturator opening.

Mortality.—Grasser's statistics showed a mortality of $78^{81}/_{100}$ per cent. in 118 cases. Meyer had a mortality rate of 54.27 per cent., Levit had a mortality rate of 50 per cent. in four cases. The fact that many of the patients are elderly women in a poor state of nutrition partly explains the high mortality; also many operations are performed late due to diagnostic delays.

CASE REPORT.—J. L. S., male, aged sixty-five years, farmer, entered Tennessee Copper Co. Hospital at 1 P.M. June 27, 1915, referred by Dr. J. M. Daves, of Blue Ridge, Georgia. History of complete intestinal occlusion since June 19. Said he had been troubled by a hernia for four years and it "caught on him" June 19. Claimed he could feel the hernia slip out and could usually get it back, but on this occasion he could not do so.

Pain and shock at first, afterwards complete constipation and profuse vomiting. Operation urged by Dr. Daves and consultant, Dr. Tankersley, of Ellijay, Ga., when they saw patient on June 20.

Patient steadily refused until June 27. No flatus passed with numerous enemas.

Examination.—Temperature $99^{2}/_{5}$, pulse 104, regular and full, white blood count, 10,000; urine negative; abdomen not much distended; large right-sided hydrocele; inguinal and femoral canals apparently normal; no fulness in right obturator region, although patient was considerably emaciated and palpation facilitated.

Romberg's sign present and a peculiar tense mass could be made out on rectal palpation; general condition seemed excellent under the circumstances.

The patient was positive of the existence of a hernia which he was ordinarily able to replace by manipulation and he referred its location to the obturator region. However, he claimed that he had derived benefit from a truss bought and fitted by himself which did not coincide with our ideas of obturator hernia. Obviously, an immediate operation was imperative, so he was prepared at once.

Operation.—Ether anæsthesia, iodine preparation. We decided to at first explore the inguinal and femoral region through

a Bassini incision and if the source of trouble was not found to make an abdominal section. Rapid Bassini exploratory incision revealed right inguinal and femoral regions normal, so abdomen was opened in median line. Small intestine was found distended, cæcum collapsed, coil of small intestine found incarcerated in right obturator opening and held under considerable tension. Cautious examination showed the incarceration very firm and, as it had existed eight days, it was deemed advisable to open the obturator region and fully free the sac as a preliminary to reduction. The pectineus muscle was exposed by the usual vertical incision inside the femoral artery and its fibres separated. A hernial sac was found rather small and tightly bound down by numerous tough adhesions.

The sac was thoroughly freed by blunt dissection and, when it was held up for inspection preparatory to opening the herniated bowel, reduced itself. The end of the sac was secured by a forceps and the bowel inspected through the abdominal opening. There was no evidence of circulatory impairment and the condition seemed excellent except for a few abrasions of the serous surface near the mesenteric border. These were repaired by silk Lembert sutures.

The obturator opening was examined and the sac was found empty.

The opening barely admitted the tip of the index finger. The abdominal incision was closed. The sac was then ligated and cut off high up and the obturator incision closed. The condition of the patient seemed very good, so the right testicle was brought through the inguinal incision and the hydrocele quickly operated by the eversion method of Jaboulay. The inguinal incision was closed and the patient left the table with no evidence of shock and in very satisfactory condition.

Subsequent Course.—Gas was passed freely a few hours after the operation and excellent results obtained from an enema the following day. Recovery was absolutely uneventful and the patient protested vigorously against the cautious administration of liquid nourishment during the first few days of his convalescence. He left the hospital July 15, in excellent condition.

CONCLUSIONS

First, the difficulties attending diagnosis of obturator hernia are well illustrated in this case. In spite of the fact that this patient gave a clear history of hernia referred to the obturator region and that his emaciation facilitated palpation, a positive diagnosis could not be made without abdominal section.

Second, in view of the difficulty of positive diagnosis and the difficulty of exposing the obturator region by dissection, a preliminary median abdominal laparotomy seems a very sensible procedure in suspected cases of obturator hernia. It has the following points of advantage:

(*a*) The diagnosis is cleared up at once.

(*b*) The possibility of making an exposure of the obturator region only to find no hernia there is avoided.

(*c*) The abdominal incision greatly facilitates any necessary repair of the herniated intestine.

(*d*) In cases where the condition of the patient demands quick work, the hernia can be reduced from within the abdomen, relieving the constriction under direct inspection with the patient in the Trendelenberg position. The obturator opening could then be closed by a few sutures from within.

(*e*) When the patient's condition permits the obturator region can be exposed and the sac dissected free and ligated. Inasmuch as it establishes diagnosis at once and facilitates subsequent operative procedure, preliminary laparotomy seems extremely rational.

Third, the modern system of prompt laparotomy in the early stages of all cases of intestinal occlusion will, no doubt, very much lower the mortality rate in future cases of obturator hernia.

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THE PROSTATE GLAND IN OLD AGE

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This report concerns the anatomical structure of the prostate gland in old age. Seventy-one specimens varying in age from sixty-two to seventy-nine years have been studied. Observations of the gross specimens have been carefully made. Sections taken from various parts of the gland have been cut and stained in the usual manner and studies have also been made of complete serial sections of the entire organ from its apex to the base and also include the vesical sphincter and the entire trigonum vesicæ. In staining these sections various dyes have been used. Most of them have been stained with hæmatoxylin and eosin. In a large number of instances Van Giesen's stain for the differentiation between smooth muscle and connective-tissue cells has been utilized as well as Weigert's elastic tissue stain.

It seems appropriate to review very briefly the embryology and anatomical changes in earlier years before taking up the discussion of structural changes in old age. As has been pointed out in a previous communication, the prostate originates from five independent groups of tubules which begin to develop in the wall of the posterior urethra at about the twelfth week of intra-uterine life. (*a*) The middle lobe is usually made up of about nine or ten tubules originating on the floor of the urethra between the bladder and orifices of the ejaculatory ducts. There may be an absence of the middle lobe, in which case there is an ingrowth of tubules from the lateral lobes. (*b*) The posterior lobe is an independent structure, being made up of twelve tubules which originate from the floor of the prostatic urethra below the orifices of the ejaculatory ducts. They grow posteriorly behind the latter structures and are in no sense a glandular commissure, as they are definitely separated from the other parts of the gland by a lamella of connective tissue. (*c*) The anterior lobe is fairly large until the sixteenth intra-uterine week, after which it seems to decrease in size and importance. At birth it is very small.

The so-called accessory or contiguous structures are interesting, and as their development and later changes are quite important they will be briefly mentioned.

The subtrigonal mucous glands are noted as early as the twenty-

second week of intra-uterine life and are comparatively few in number, the average in all embryological specimens studied being six.

The subcervical glands of Albarran occur in all specimens older than the fifteenth week of intra-uterine life. They average twelve in number during this period.

The seminal vesicles originate at the thirteenth week and appear at first as an evagination lateralward from each vas deferens. They grow backward and laterally, consisting of a main part which is convoluted and from which rather numerous, short, convoluted branches grow out, as described by Pallin.

The vasa deferentia and ejaculatory ducts are at first exceedingly large, comparatively speaking. Later on, as the embryo becomes more mature, they are outgrown by surrounding tissues and hence are comparatively smaller. As these structures approach the lumen of the urethra its floor is pushed up into a mound, converting it into a semilunar-shaped passage and forming the verumontanum.

Before the fifth month the utricle in nearly every instance extends to the base of the prostate. After that age it is usually found in the tip of the verumontanum.

In the wall of the urethra just at the apex and a little below it there are found in the older specimens delicate tubules with a few branches. They are not connected with the prostate and extend only slightly into the muscular walls of the urethra. They disappear lower down in the urethra.

In early embryonic life the peritoneum covers the posterior surface of the prostate and seminal vesicles, extending as far as the apex of the former. Later on this peritoneal sac becomes pinched off, as is beautifully shown by several of Dr. Franklin P. Mall's specimens, and has been described by a French writer, Denonvilliers, whose name the resulting fascia bears.

In old age the prostate lies behind the second portion of the rectum at the neck of the bladder, which it surrounds posteriorly and laterally. It is firmly attached to the vesical orifice and urethra and is encircled by the prostatic fascia. It is held in position by several structures. Its apex is suspended superiorly by the puboprostatic ligament which connects it with the pubic bone on either side. The anterior surface is separated from the symphysis pubis by a space 1.5 cm. to 1.1 cm. in size and gradually increasing from above downward, filled chiefly with a fatty cellular substance and a dense venous plexus. Inferiorly it is joined to the rectum by the recto-urethralis muscle, which is a reflection of the anterior portion of the levator ani muscle. The deep layer of the

triangular ligament aids in fixing the apex because it invests the membranous urethra and is attached to the prostate. The lateral borders of the gland are embraced by portions of the levator ani muscle, which are separated from direct contact with it by a plexus of veins.

The shape of the prostate changes markedly during various stages in its development. At the very first appearance during the latter portion of the third intra-uterine month it exists as a cylindrical mass surrounding the posterior urethra, the mass being a little more pronounced on its posterior aspect. About the seventh month the lateral borders near the base become quite bulging in character, due to the fact that the lateral lobe tubules grow more extensively than do those of other portions of the gland. At the time of birth the gland is slightly more flattened than during the seventh month and also a little larger. Between the time of birth and the beginning of puberty there is very slight change in the shape of the organ. During the adolescent period the prostate changes markedly. It loses most of its rounded appearance and rapidly assumes the appearance of the adult organ. The length of the prostate in every instance is greater than its thickness and always less than its width.

In shape the adult prostate has often been likened to a horse-chestnut flattened on one side, but this comparison seems to be insufficient. Its posterior surface is triangular and flattened. It usually has a depression extending longitudinally in its midline which is most prominent towards the base of the gland and rarely, if ever, exists at the anterior one-third. Its upper border or base bulges on each side as do the lateral borders. The anterior surface is rounded and most of the vessels of the prostate occur here and at the lateral borders, very few being found on the posterior surface or at the base. The base receives the ejaculatory ducts after the junction of the vasa deferentia with the seminal vesicles in an elliptical funnel-shaped depression. Geometrically the prostate has been called an oblate conoid or truncated cone.

The size of the prostate shows marked changes at various stages in its development, as is shown in the accompanying table. The development from the actual period of origination until the time of puberty seems to be upon the whole a fairly regular and gradual increase in size. At five years of age the gland is surprisingly little larger than it is at birth. The average length during the first half of the first decade is 1.2 cm. The width is 1.5 cm. and height 0.9 cm. Cuthbert S. Wallace states " at the eighth year the prostate has increased somewhat in size, and taken on more or less the adult form. In regard to its

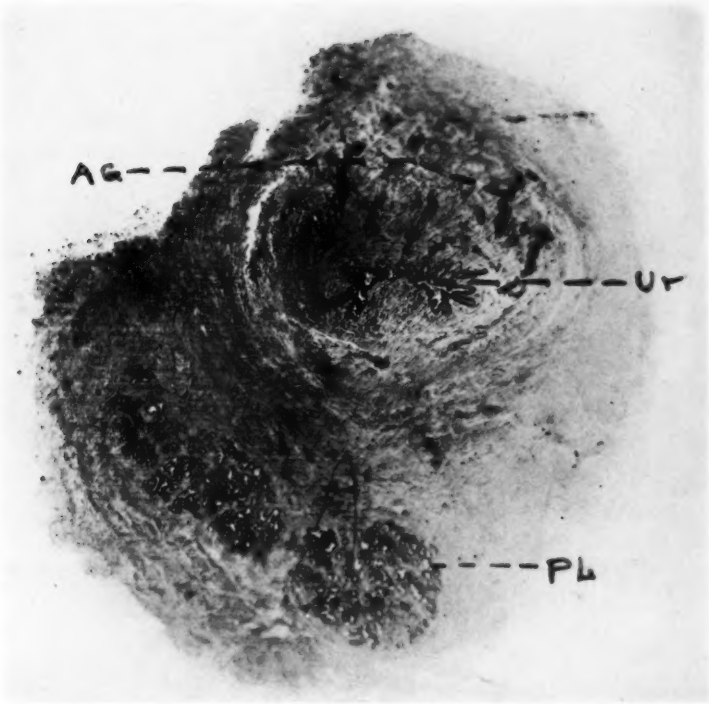

FIG. 1.—Cross-section through urethra at apex of prostate, showing tubules of the apex group. *PL*, forward branches of the posterior lobe of prostate; *Ur*, urethra; *AG*, tubules of apex group of glands. Specimen seventeen years of age.

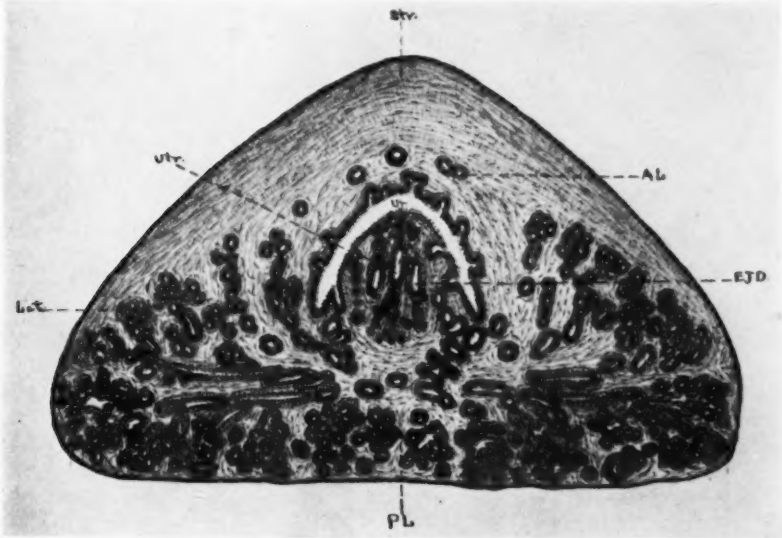

FIG. 2.—Cross-section through middle of verumontanum and prostate of a boy aged four years, stained according to Van Giesen's method. *Ur*, urethra; *Utr*, utricle; *EJD*, ejaculatory ducts; *Str*, striated muscle fibres; *AL*, anterior lobe tubules; *Lat*, lateral lobe tubules; *PL*, posterior lobe tubules.

FIG. 3.—Oblique section through the prostate, trigonal region of a man aged seventy-six years. *Ur*, urethra; *AG*, Albarran's subcervical gland tubules; *VS*, vesical sphincter; *ML*, middle lobe tubules; *EJD*, ejaculatory ducts and muscular envelope; *PL*, posterior lobe tubules; *Lat*, lateral lobe tubules.

FIG. 4.—Cross-section at the level of the region just above the upper end of the verumontanum of a man thirty-four years of age (section cut slightly obliquely). *Ur*, urethra and portion of bladder lumen; *AG*, Albarran's glandular tubules; *ML*, middle lobe tubules; *Lat.*, lateral lobe tubules; *PL*, posterior lobe tubules; *Utr*, utriculus prostaticus and ejaculatory ducts bound firmly together in envelope.

increase in size, there does not appear any increase in the glandular elements. At eighteen years the organ has increased in size, but the glandular elements are but scantily developed. Between twenty and twenty-five years the prostate is fully developed and becomes an essentially glandular organ." My investigations do not entirely bear out these statements, as observations on fifty prostates between the ages of birth and twenty years seem to indicate a rather gradual increase in the number and size of branches of the tubules up to the period of puberty, at which time there is a tremendous increase in the glandular elements, as is shown in comparing Figs. 1 and 2.

During the second decade there is a very great increase in size. Ten specimens over fifteen years and under twenty years average 3.0 cm. in length, which is more than twice that of the average prostate during the first decade. The average width is 3.8 cm. and the thickness 2.1 cm.

TABLE SHOWING CHANGES IN SIZE OF THE PROSTATE GLAND AT VARIOUS AGES

Age	Number of cases	Length		Width		Height	
		Variation	Average	Variation	Average	Variation	Average
		cm.	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
First decade... (1–10 years)	38	1.0–1.7	1.2	1.0–2.0	1.5	0.7–1.3	0.9
Second decade.. (10–20 years)	10	2.5–3.5	3.0	.....	3.8	1.8–2.4	2.1
Third decade... (20–30 years)	40	2.8–4.0	3.3	3.6–5.2	4.1	2.0–3.0	2.4
Fourth decade.. (30–40 years)	33	2.4–4.0	3.15	3.0–5.0	4.1	1.6–3.0	2.55
Fifth decade... (40–50 years)	42	3.0–4.6	3.45	3.6–5.0	4.0	2.3–3.8	2.65
Sixth decade... (50–60 years)	29	2.4–4.5	3.65	3.3–5.0	4.37	2.4–3.4	2.75
Old age..... (60 years+)	32	2.6–4.5	3.23	3.0–5.0	4.12	2.0–3.6	2.47

The proper way to consider the size of the prostate seems to be to group the various specimens into decades and the figures obtained have been arranged in a table. Inspection of this table shows that the prostate gland reaches adult size during the third decade. Changes occurring after that period are comparatively slight. The average length is 3.3 cm., width 4.1 cm., and height 2.4 cm.

The figures quoted by all authors seem to vary slightly. Wilson and McGrath consider the average adult prostate to be 3.4 cm. in length, 4.4 cm. in width, and 1.5 cm. in thickness; weight 16 or 17 grammes. Cuthbert Wallace places its dimensions at 3.0 cm. for length,

width 3.6 cm., thickness 1.8 cm.; average weight 20.5 grammes. Sir Henry Thompson states the average measurements in fifty normal adult prostates to be as follows: Length 1.4 inches, width 1.75 inches, thickness 0.7 inch, weight 4 drachms and 38 grains. These figures correspond fairly well with those of Deschamps,[5] Senn,[31] Gross,[12] and Hodgson,[14] but are somewhat smaller than those of Dupuytren.[7]

During the fifth and sixth decades in life there seems to be a slight increase in all of the dimensions of the prostate, but considering all specimens this only amounts to a few millimetres. During the period of old age there is a drop back in size so that these specimens resemble those of the third decade more closely than any of the others. It is noticed in examining the glands of this period that they are either a little smaller in size and atrophied in appearance than those of the preceding period or a little larger and inclined to have the appearance of an hypertrophied condition. The specimens of this period have more abnormalities than those of any of the others; 56.1 per cent. of all specimens observed showing some deviation from the normal. Thirty-three per cent. of the prostates over sixty years of age show more or less a condition of adenomatous hypertrophy.

In cross-sections through its middle portion the prostate gland seems to be made up of concentric layers of tissue. The innermost or central area consists of the horseshoe-shaped urethra with the verumontanum which is made up of the ejaculatory ducts and utricle with their muscular and connective-tissue walls, the terminal ends of the prostatic tubules with their rather thinly disposed circular layers of muscle. The stroma of this layer is not very abundant and is made up of connective tissue for the most part with a moderate amount of smooth muscle-fibres but practically no elastic tissue-fibres. The next layer in the lateral and posterior directions is made up for the most part of stroma with practically no tubular tissue except the ducts proper, which have very few branches. The stroma is largely made up of connective tissue with a generous sprinkling of smooth muscle-cells which are not arranged in definite bundles except around the tubular ducts, where there are two layers, the inner circle which is quite thin and the outer longitudinal which is comparatively thick. There are a moderate number of elastic tissue-fibres here also. In the anterior region there are observed the tubules of the anterior lobe with a very slight amount of muscle around them quite firmly imbedded in the stroma, which consists in the anterior region of the middle concentric layer of a considerable number of smooth muscle-fibres interspersed with the white fibrous tissue bundles with occasional fibres of elastic tissue. Near the upper

border of the layer are seen a few bundles of striated muscle-fibres which in my specimens have not been found to exist among the tubular branches. Wallace, however, reports that he has observed them around some of the peripheral branches of lateral lobe tubules. The outermost of these concentric layers is exceedingly interesting, as it contains practically all of the branches of the posterior and lateral lobe tubules. The middle and anterior lobes are contained for the most part in the middle concentric layer. In the outer layer there is a great preponderance of muscular tissue and mucosa over all other elements of the gland. In the posterior and lateral portions the muscular tissue is practically all smooth and surrounds the tubular elements as has been described. In the anterior portion and extending down the lateral borders almost to the posterior surface are found the striated fibres which make up the so-called muscle of Henle. This muscular tissue is so arranged that near the most anterior portion of the gland it is almost the only tissue present. Looking from this point towards the urethra it is seen to become less and less, gradually shading off and being scattered among the smooth muscle and connective-tissue fibres so that at the edge of the middle concentric layer there are only occasional fibres noted. There is less and less striated muscle down the lateral borders of the gland until it finally disappears altogether.

There are islands of lymphoid tissue scattered here and there in the adult prostates. Rarely one finds some of these areas in the prepuberty specimens. They seem to be most frequently met with in specimens older than thirty years. Waldeyer has found similar areas in the prostate of a dog and Weski has studied them in the human and believes them to be normal anatomical structures.

The base of the prostate is intimately attached to the musculature of the bladder.

In regard to the internal sphincter of the human bladder Versari concludes from his investigations: (1) The smooth muscle sphincter of the urinary bladder of man constitutes a structure by itself, which develops independently of the middle layer of the bladder, the circular muscle layer of the urethra and the musculature of the ureters. (2) The sphincter is made up of an urethral and a trigonal portion, and it is the urethral portion only which assumes the form of a ring surrounding the initial part of the urethra. The first groups of the fibres of the sphincter arranged in bundles correspond to the anterior arch of the urethral portion; from there immediately follow those of the urethral portion of the posterior arch, and these last are apparently

those of the trigonal portion. The posterior arch of muscle extends, little by little with new bundles, either upward to occupy part of the trigonal area, or downward along the posterior wall of the urethra, so that it comes to have an extent much greater than the anterior. On the other hand, the older view held by Krause, Hyrtl, Gegenbauer and others is that the sphincter is a continuation downward of the circular musculature of the bladder. The study of sections including the vesical sphincter in this series bears out the conclusions of Versari in regard to its structure.

The capsule of the prostate is composed of a structure which is made up of closely knit connective-tissue fibres and surrounds the entire organ except at the base between the entrance of the ejaculatory ducts into the substance of the prostate and the junction of the bladder wall with the gland. Here the tubules of the middle lobe are almost free and have as a consequence very thick muscular and connective-tissue walls. The large blood-vessels which supply the prostate run in the capsule and intralobular partitions for the most part and are most numerous on the anterior portion of the capsule.

The glandular elements of the prostate are in every instance divided into five portions corresponding to the five original groups of tubular evaginations noted in the embryo. The division between the middle and two lateral lobes becomes less and less noticeable as age advances, but the orifices of the middle lobe tubules are always widely separated from all other tubular orifices and quite closely grouped together. The middle lobe tubules always grow backward posteriorly to the broad ribbon-like sphincter of the vesical orifice and its tubules are never found imbedding themselves in it or extending within the sphincter. This is an important fact to be noted when considering pathological conditions at the vesical orifice.

The lateral lobes during the period of middle age become more and more prominent and cause a bulging of the lateral surfaces to a marked degree, thus making the transverse diameter of the organ proportionately greater than the prepuberty specimens studied. The number of branches of these and tubules of other lobes of the prostate are markedly increased but the number of tubules is certainly not increased and seems rather to be decreased, but this is a variable matter which is undoubtedly determined in the embryo and the exact number is a personal characteristic.

The posterior lobe is fairly well separated from other portions of the gland and is divided off by a rather firm and, in some instances, quite thick connective-tissue partition. It is always present as is the lobe itself and is intimately attached to the ejaculatory ducts which are not imbedded in this partition but seem to be set upon its anterior surface. This is a decidedly important matter to the surgeon in enucleating a prostate either by Squier's suprapubic intra-urethral method, in which the enucleating finger approaches the partition and attached ejaculatory ducts and passes along to the upper

end of the verumontanum, which is usually removed without injuring the ducts and which surely would not be injured if the verumontanum, which is usually torn through with some difficulty, were cut with the scissors; or Young's perineal method, in which the two parallel longitudinal incisions must be extended through the partition, thus preserving the ejaculatory ducts, in order that the enucleating instrument may go into the lateral lobe cavities, because otherwise it will lead into the capsule of the gland and proper enucleation is then an impossibility. The posterior lobe is the part of the gland felt per rectum. Its tubules are in most respects similar to those of the other lobes. In some cases, however, they seem not to be quite so large and in most instances there is evidence that they do not secrete prostatic fluid actively. The branches of these tubules are usually not as numerous as those of the other lobes and have a thinner layer of muscle surrounding them.

The anterior lobe varies greatly in different specimens. At the time of birth it consists of two small unimportant tubules with very few branches. In the postpuberty specimen the anterior lobe is quite prominent and is made up of tubules which branch extensively and are apparently actively secreting prostatic fluid. A number of important changes are noted when the prepuberty prostates are compared with the gland in adult life. The mucosa of the terminal branches of prostatic tubules in prepuberty specimens is made up of cuboidal-shaped cells with nuclei which are quite large and situated in the centre of the cells. They are usually two layers thick and occasionally three. Scattered here and there are occasional cylindrical-shaped cells with the nuclei elongated and in the centre of the cell. The lumina are very small and apparently devoid of secretion. The mucous cells are placed upon a felt-like base made up of minute connective-tissue fibres, as described by Walker. The smooth muscle layer surrounding the terminal branches are very interesting as brought out by Van Giesen's differential stain. Each branch is surrounded by a definite layer of smooth muscle circularly arranged. The branches occur in groups of 5 to 10 and the entire tubule is surrounded by a much heavier envelope of smooth muscle also circularly arranged. Outside of this envelope there are several small bundles of longitudinal fibres which occur at intervals around the tubule but not as a definite intact sheet. The branches of tubules all extend backward towards the base of the prostate with the exception of a few of the most anterior tubules of the lateral and posterior lobes. The collecting ducts are situated at the most anterior portion of a given group of branches and pass directly towards the verumontanum so that almost the entire duct, with the exception of a very small portion which turns forward, may be seen in one cross-section. The ducts are lined by mucous membrane which resembles that already described in practically every detail. There is, however, a great difference noted in the arrangement of the musculature. A thick layer of smooth muscle surrounds the ducts but it is arranged almost entirely in a longitudinal direction, very little circular muscle being noted. There are practically no branches from this part of the tubule, most of them occurring in the peripheral third of the gland. In the verumontanum the tubule turns and runs forward for a slight distance again and about nine-tenths of them open on the lateral walls of the verumontanum in such a manner that there is a little leaflet of tissue covering the orifice which is an exceedingly

important factor in protecting the tubules of the gland from an inpouring of urine and other foreign matter when the posterior urethra is put under pressure. The direction of the openings of the tubules of the prostate and ejaculatory ducts is an important consideration also because instrumentation will frequently cause an infection by forcing foreign substances into them. In the adult prostate there is noted a great change in the mucosa. I have found in my specimens that the tubules and their branches are lined by a single layer of high cylindrical cells with the nuclei at their bases. Occasionally there is inserted between the bases of adjoining cells a round or conical cell, as Krause pointed out. In some cases there is a piling up of the cylindrical cells, but I have not found that there is a double layer of cylindrical cells in all of the terminal branches as Langerhans states. Near the orifices of the ducts the epithelium is transitional in type, being similar to that of the urethra itself. The muscle bundles surrounding the tubular branches are very thick in the peripheral portions of the gland and particularly in the case of middle lobe tubules near its base. These muscular bundles are much more pronounced comparatively speaking in the case of the younger specimens than in the older and this is probably due largely to the fact that the entire gland becomes more compactly arranged after puberty.

Some of the older writers gave very interesting reports upon the minute anatomy of the prostate. Dr. Hansfield Jones [18] in 1847 affirmed that pale or unstriped muscle entered largely into the composition of the gland. Kölliker [21] in 1848 declared that the larger part of the organ was constituted of pale muscular tissue and that the smaller portion only consisted of glandular tissue. Professor Ellis [8] of University College in 1856 declared the prostate to be essentially a muscular body: "as only so small a portion of the prostate is glandular, the propriety of calling that body a gland is rendered doubtful, for the small secreting glands contained in it are but appendages of the mucous membrane which project amongst the muscular fibres in the same way as the other glands of the urethra extend into the surrounding submucous tissues." Jarjavay partly confirmed the above view also.

Sir Henry Thompson wrote as follows in 1873: "The glands themselves are somewhat peculiar and characteristic of the prostate. They are classified as multilobular or compound racemose. The walls of the vesicles and crypts are covered with an extremely regular epithelium, the cells of which show a disposition to be ovoid but apparently become polygonal under the influence of lateral pressure. The ducts are lined with prismatic cells."

Rüdinger states that no other viscus encloses within itself so great a number of muscular fibres in such a limited area as the prostate, especially where the glandular substance is subordinate to the muscular layers.

A specimen obtained from a man seventy-six years old (Fig. 3) who died of cerebral lues bears out in a general way the findings observed in the younger specimens described. There is, however, a difference noted which is interesting. The tubules are for the most part collapsed and show definite signs of atrophy. Here and there are seen corpora amylacea of various sizes.

The Middle Lobe.—Ten moderately large, numerously branching tubules form the middle lobe which is in this instance usual in size. The course of the tubules is similar to that of like structures already mentioned and the ducts open on the summit of the verumontanum and its lateral surfaces above the point where the ejaculatory ducts empty into the urethra. There are a number of corpora amylacea present and only a few of the tubules are distended, most of them showing signs of atrophy. They extend behind the vesical sphincter to a level with its upper border. In most places it is easy to distinguish the point of separation between the middle and lateral lobes, although there is not a well-defined wall of tissue separating them at all points.

Lateral Lobes.—The largest portion of the gland is occupied by twenty-four tubules which are contained within the two lateral lobes. Corpora amylacea are present and a few of the lumina are distended, but for the most part are collapsed and show definite signs of atrophy. The lumina are almost entirely obliterated in some instances, being occupied by a shrunken and distorted mucosa, while the muscle-bundles are not nearly so thick and distinct as those observed in younger specimens. The course of the tubules follows very closely those previously described. They open a little below the mouths of the ejaculatory ducts in the prostatic furrows or on the lower lateral surfaces of the verumontanum. A few of them open into the prostatic furrows above and below this point and a few open upon the lateral walls of the urethra itself.

The Posterior Lobe.—This is definitely separated from all other portions of the gland by a thick, well-defined layer of muscle and connective tissue. The separation is more complete in this instance than it is in any other gland studied. The tubules, eleven in number, have grown back to a point behind the ejaculatory ducts and reach the same level as do those of the lateral and middle lobes. The branches are numerous but not large and invariably show a distinct atrophy. There are a few corpora amylacea in these tubules and where they occur the lumina are entirely occupied by the laminated bodies, the walls of the tubules being contracted upon them and much constricted before and behind. The ducts of the posterior lobe tubules proceed behind the ejaculatory ducts and empty into the urethra upon its floor outerward from the verumontanum as far as the apex of the gland. The outermost tubules have branches which extend forward.

The anterior lobe is comparatively large in this specimen. It is made up of five tubules which are quite as large as those of the other lobes. These tubules have many branches, some of which are distended but most of which show signs of atrophy as do those of the other lobes. The ducts of this lobe empty into the urethra upon its ventral and lateral walls. They are not grouped near the mouths of the ejaculatory ducts as are those of the middle and lateral lobes but enter indiscriminately. Histologically these tubules present an appearance similar to that of the tubules of other lobes.

The mucous membrane of the tubules of this specimen is quite interesting. In the prepuberty specimens it is composed of epithelial cells piled two or three

deep, with nuclei which are elongated and almost fill the cell. The lumina of the tubules of that period are very small and show no evidence of containing secretion. In early adult life and middle age the mucosa in most cases is composed of a single layer of high columnar epithelium with a granular protoplasm and a fairly small round nucleus situated near the base. There are occasional conical cells placed here and there between the bases of the others and the entire epithelium placed upon a felt work of fibrils of connective tissue. The lumina are large and filled with secretion. Rarely there is seen a corpus amylacea. There are folds in the epithelial lining of normal middle-age specimens but very few finger-like projections or bridging of epithelium, such as is noted in adenomatous hypertrophy. In this specimen the mucosa is composed of columnar epithelium cells of the usual type but the individual cells are not so clear cut. Their nuclei are somewhat smaller and stain more deeply. Very few of the lumina are distended. Most of them are collapsed and show little or no evidence of secretion. The mucous layer is in many instances shrunken and distorted. Corpora amylacea are fairly numerous. They usually occupy the entire lumen of the tubule, the walls being contracted tightly down upon them. The smooth muscular envelopes retain their characteristic arrangement but are atrophied in appearance. There is a moderate amount of lymphoid tissue here and there throughout the stroma. By utilizing Van Giesen's differential stain it has been determined that in the middle lobe 25 per cent. of the stroma is composed of smooth muscle. In the lateral lobes 25 per cent. is smooth muscle and 10 per cent. striated muscle. The posterior lobe, like the middle lobe, contains no striated muscle and the stroma contains about 25 per cent. smooth muscle. The anterior lobe stroma is made up of 30 per cent. striated muscle, 25 per cent. smooth muscle and the remainder connective and elastic tissue fibres.

In youth before puberty the comparison between glandular tissue and stroma is about one to five. After puberty in the adult it is one to three, and in normal old age one to four.

The subtrigonal glands are present but are small in size. They are similar in type to those already described as regards their histology and location. In this specimen twenty-one of them are found between the middle of the trigonum vesicæ and the vesical orifice. In no instance do any of them have branches and they do not extend through the submucosa.

The tubules of Albarran, thirty-three in number, are found in their usual location. They seem rather more extensive in this specimen. The uppermost branches have grown to a point on a level with the upper margin of the vesical sphincter. They are contained within the sphincter and for the most part are embedded in the submucosa, although a few branches have extended for a short distance into the muscularis. Most of these structures empty into the urethra near the upper end of the verumontanum but there are a few that have their openings between this point and the vesical orifice on the floor of the urethra. The tubules have quite a number of branches and their histological characteristics are similar to those already described in other specimens. An interesting feature of this particular group is that quite a number of the tubules are distended, in some cases reaching five or six times the usual size.

The verumontanum is usual in shape and its length is 1.85 cm., being 0.5 cm. high and 0.43 cm. broad at its base. About 15 per cent. of the stroma of

the verumontanum is smooth muscle, the remainder being entirely composed of connective tissue, as there is no elastic tissue present in this structure.

The utriculus prostaticus is present and fairly large in size. It is found only in the verumontanum and ends in a bicornuate manner. It opens in the midline on the crest of the verumontanum below the mouths of the ejaculatory ducts and is surrounded by a number of large tubules, some of which empty into the utricle and a few of which empty into the urethra itself. The muscular walls surrounding the utricle are quite thick and prominent. The ejaculatory ducts accompany the utricle and the three structures are firmly held together by a thick muscular envelope which also surrounds the tubules mentioned above. The mucosa of the utricle is thrown into numerous folds and the lumen of the structure is almost filled with them.

The vasa deferentia are thick walled and retain their customary shape and appearance. Occasional simple tubular glands without branches are seen in their walls and communicate with the lumina. The ampullæ of the vasa deferentia are large in size and have a folded mucous membrane which almost occludes the lumina.

The seminal vesicles are collapsed and the mucosa folded. They are made up of a main chamber on each side with five small branches which are much folded and contained within a fibrous sheath. Their walls are thick and compact. They are surrounded by a rather rich blood supply which traverses the fibrous tissue between the convolutions of the various portions of this structure.

The ejaculatory ducts formed by the junction of the mouth of the seminal vesicle on each side and the vasa deferentia begin well within the substance of the prostate and proceed in an oblique direction until they reach the level of the upper end of the verumontanum, at which point they turn abruptly and pass almost perpendicularly up into the verumontanum, where they become separated by the utriculus prostaticus which is contained in the same thick sheath with them. They run parallel with the axis of the urethra for a considerable distance and then each one turns sharply laterally and empties into the urethra on the sides of the verumontanum in such a manner that a thin area of tissue extends over the mouths of the ducts.

The Apex Group.—There are twelve small tubules with a few minute branches which make up the apex group of glands. These are delicate in their outlines, small in size and do not have thick muscular walls. They are found for a short distance in the membranous urethra as well as surrounding the urethra at the apex of the prostate. They do not extend deeply into the peri-urethral tissues. They are similar in type to those observed in other specimens.

The number of prostatic tubules is a subject that has been much discussed and concerning which there is a great deal of divergence of opinion. Svetlin by counting the excretory ducts has determined the number to vary between fifteen and thirty-two. I am convinced that in health most of the prostatic duct orifices are invisible to the eye or the cysto-urethroscope of Buerger or McCarthy. I have used the latter instrument repeatedly on a large number of cases and rarely have

been able to count more than fifteen duct orifices and these have usually been in pathological conditions in which they were held open due to induration of the tissues composing them. As has already been explained earlier in this paper, the prostatic tubules open into the urethra at an angle and in such a manner that the orifices are protected by a thin valve-like lappet of tissue which usually drops down over the orifices and closes them quite effectively, particularly upon distention of the posterior urethra. Kölliker has estimated the tubules to be thirty to fifty in number; Hessling fifteen to thirty. From the investigations made here it seems to be a much more accurate method to study the entire prostate gland, and in following the various tubules from section to section the exact number of tubular ducts opening into the urethra can be determined for each lobe of the prostate. By pursuing this method in twelve cases, varying in age from two and one-half months intra-uterine to seventy-six years of age, it has been found that the number of tubules of the prostate varies from forty-one to seventy-four, the average for all specimens observed being fifty-eight.

TABLE SHOWING NUMBER OF PROSTATIC AND OTHER TUBULES WHICH ENTER THE URETHRA

No.	Age of specimen	Middle lobe	Lateral lobes		Posterior lobe	Anterior lobe	Total prostatic tubules	Subcervical glands Albarran	Subtrigonal glands	Apex group
			Right	Left						
1	2½ months; intra-uterine.....	0	0	0	0	0	0	0	0	0
2	3¼ months; intra-uterine.....	12	20	19	11	12	74	0	0	0
3	.....	7	13	14	6	13	53	0	0	0
4	4 months; intra-uterine.....	10	23	23	4	14	74	8	0	0
5	4½ months; intra-uterine.....	0	21	21	10	7	59	11	5	0
6	7½ months; intra-uterine.....	11	18	18	9	8	64	9	4	12
7	At birth.....	9	17	17	11	2	56	19	9	19
8	4 years.....	12	10	14	11	5	52	33	23	26
9	4 years; Dr. Vance's specimen..	7	11	12	8	4	42	39	?	?
10	17 years.....	12	11	11	12	5	41	43	32	16
11	35 years.....	7	15	11	11	4	48	31	38	9
12	76 years.....	10	12	12	11	5	50	33	21	12
	Average.....	10	16	16	9	7	58	25	19	15

The five original independent lobes of the prostate have been distinguishable in every specimen observed in this research. The middle lobe has been definitely absent in one intra-uterine specimen, in five cases there has been some doubt about its presence and in 447 cases it has been definitely present, as shown in the accompanying table. Thus it is seen that this investigation bears out the statements of Griffith who

declared that (1) the middle lobe may be either present or absent at the time of puberty and in adult life before enlargement takes place; (2) that this lobe is independent, having glands of its own which open upon parts of the posterior wall of the prostatic urethra. Tandler and Zuckerkandl [32] agree with this opinion and base their theory of prostatic hypertrophy largely upon this anatomical fact. Pallin,[26] Evatt,[9] Jores,[19] and others consider the middle lobe to be a glandular outgrowth from each lateral lobe.

TABLE SHOWING THE FREQUENCY OF THE OCCURRENCE OF MIDDLE LOBES

Specimens	Number of definite middle lobes	Questionable middle lobes	Middle lobes definitely absent
Twenty cadavers in Dr. Mall's laboratory	20	0	0
Ten fœtuses	9	0	1
Thirty-three enlarged prostates in museum of Brady Institute of Urology	31	2	0
Forty autopsy specimens of enlarged prostates in Guy's Hospital, London	37	3	0
Three hundred fifty post-mortem specimens, Bellevue and Post-Graduate Hospitals, New York	350	0	0
Total	447	5	1

The number of tubules composing the middle lobe varies from 0 to 12, the average being 10. The average number of tubules in each lateral lobe is 16, as few as 10 being found and as many as 21 in one case. The posterior lobe tubules vary from 4 to 12, the average being 9. The anterior lobe was found to be least conspicuous in the prostate of a new-born child which was exhaustively studied and remodelled in wax. Another specimen showed as many as 14. After birth this particular group of prostatic tubules never numbered more than 5, although in a specimen observed just after puberty its tubules seem to be as actively functionating as any other portion of the structure. The average number for all specimens is seven.

The structures, which have been termed in this investigation "accessory organs," are interesting, and a discussion of histological characteristics seems proper.

The trigonum vesicæ was shown by Lieutaud to be superimposed upon the vesical floor, its constituent fibres coming from each ureteral wall. J. Griffiths [11] believed it to be composed only of the innermost bands of muscular bundles of the bladder wall. W. Waldeyer [37] believes that there is a separate development of its musculature which is continuous with that of the ureters and the prostatic urethra. There

is an absence of submucosa over the trigone. It has firm, smooth, thick-layered muscular membrane. Versari [35] concludes from his studies that normally the musculature of the trigonum vesicæ is made up of (*a*) the trigonal portion of the internal sphincter, (*b*) part of the muscular layers of the ureters, and (*c*) the muscle-bundles of their sheaths. In adults there are present in the trigonal region bundles which come from the muscular layer of the bladder. Walker [36] agrees with the above in part. He observes that from the ureter on each side a thick band of muscle passes down towards the urethra. These bands converge and unite so that this longitudinal muscle flows over the margin of the urethral opening in a continuous sheet. In the centre of the triangle formed by these bands of muscle the fibres appear to interlace indiscriminately. Delbet [4] declares the trigonum vesicæ to be an appendage of the ureteral walls. Congenital lack of an ureter shows the trigonum to be lacking on that side. Passavant has described a case in which the trigone was entirely separate from the bladder wall.

The mucosa of the trigonum is quite thick, being composed of many layers of transitional epithelial cells. This portion of the bladder mucosa is always smooth and free from folds, regardless of how trabeculated the remainder of the organ may be. The submucosa is not extensive. The group of mucous glands which I have called the subtrigonal group and which has been fully described is found extending from about the middle to the apex of the structure. There is a surprising increase in the number of tubules composing this group after birth. In an adult specimen as many as thirty-eight are observed, while before birth five is the greatest number. The average for all specimens is nineteen.

The muscle and connective-tissue bundles of the trigone are derived from the walls of the ureters and extend from the apex to the upper end of the verumontanum. The tissue composing the trigonum is very compactly arranged and this structure is very richly supplied with blood-vessels. The number of small vessels is so great that the trigonum has a dark-reddish appearance when seen post mortem or with the cystoscope.

The fibres from its apex connect with the upper end of the verumontanum and are seen to be arranged in a varying number of folds, usually two or three. This structure is normally an equilateral triangle, although the base or distance between the ureteral orifices is often a little less than the distance between ureter and the vesical orifice. In the first decade the average trigonum measures 1.2 cm. This increases in the second decade to 1.6 cm. During the third period it reaches

adult size, 2.2 cm., and remains practically the same throughout adult life.

The superposition of the trigonum upon the bladder wall, as described by Lieutaud, can be demonstrated by Mall's method, in which the structure is dissected entirely free from the vesical wall.

Asymmetry of the trigone occurs with considerable frequency. In my series it occurs most frequently in the fourth decade. Fifty-nine of the entire number of specimens, or 26.3 per cent., show a considerable difference in the distance of the two ureters from the vesical orifice. This variation may be as much as 1.2 cm. and in this day of instrumental investigation of the bladder and ureters this is an important consideration. In adults the ureters may be as near to the vesical orifice as 1.5 cm. or as far from it as 5.0 cm. Eight and one-half per cent. of my specimens have a trigonum vesicæ more than 1.0 cm. larger than normal, while 2.7 per cent. are unusually small without other signs of abnormality. Seventeen specimens, or 7.6 per cent., show an hypertrophy of the trigonum vesicæ which stands out markedly superimposed upon the bladder. It is in every such case somewhat contracted with a deep bas-fond behind its base. This condition rarely, if ever, occurs before the fortieth year.

Abnormalities in the structure of the trigonum vesicæ are very frequently met with. The existence of an hypertrophy of the group of fibres extending from one ureter to the other is so common an occurrence that a so-called interureteric bar is taken for granted in adults. I have come across a number of specimens in which there is apparently no tissue extending from one ureter to the other, but there is a distinct bundle extending from each ureter to the vesical orifice. Frequently bundles of fibres extend toward the middle line and then curve rather sharply toward the apex, forming a wide V-shaped structure. Several of the specimens show the remarkable condition of a bar extending from one ureter just to the midline where it stops off short, and extending from the other ureter to the orifice of the bladder there is a well-marked bundle of fibres.

The structure of the internal sphincter has already been discussed. The tubules which occur within the sphincter chiefly on the floor of the vesical orifice are of great interest. They were described in detail by Albarran [1] and enlargements of this group attracted the attention of authors as early as 1700. Sir Everard Home in 1802 described pathological hypertrophies of this group as the "third lobe," and such conditions even to-day are mistaken by some writers for middle lobe enlargements. As a matter of fact, true enlargements of the middle

lobe are extremely rare, while hypertrophy of Albarran's group occurs to a greater or less extent in 25 per cent. of the cases over thirty years of age, as shown by the examination of 350 postmortem specimens and about 500 cases observed by means of the cystoscope.

These tubules make their appearance at about the fourth month of intra-uterine life. They are not very numerous up to the time of birth, as there are never more than eleven. After birth they increase greatly, so that in one specimen there are as many as forty-three. The average number for all specimens is twenty-five. Structurally they differ from prostatic tubules in a number of important details. There is not a differentiated layer of muscular and connective-tissue fibres around them, although in disease the fibrous tissue develops an encircling sheath in many instances. The mucosa is composed of two or three layers of low columnar or cuboidal epithelial cells, chiefly the latter placed upon a felt-like basement membrane. The lumina are small and usually circular or oval in shape and rarely have an irregular outline with finger-like projections, as do the prostatic tubules. These tubules in an adult resemble the tubules of an embryonic prostate gland to a considerable degree.

According to McMurrich [24] the seminal vesicles begin to develop at about the third intra-uterine month. The embryonic specimens observed bear out this statement. Gustaf Pallin [26] has described very accurately the development of the seminal vesicles. They grow backward and laterally, consisting of a main part which is convoluted and from which rather numerous short convoluted branches grow out. The seminal vesicles and lower ends of the vasa deferentia are bound together by a structure composed of anterior, middle, and posterior lamella. This fascia is of interest because it tends to prevent the dissemination of carcinoma of the seminal vesicles to contiguous structures, it causes a true middle lobe hypertrophy of the prostate to project into the bladder, and it supports the base of that viscus. The seminal vesicles attain adult size during the third decade, and normally do not enlarge after that period. Histologically the seminal vesicles show a thickened wall in later years of life composed of some muscular but mainly connective-tissue fibres. These are very compactly arranged. Their lumina are quite irregularly convoluted and lined with simple non-ciliated columnar epithelium containing yellow pigment. Enlargement of these structures occurs in 32.4 per cent. of all cases over twenty years of age. The greatest period of affection is during the third decade, at which time 42.5 per cent. are abnormal. The right seminal vesicle is enlarged three times as frequently as the left in this series,

there being thirty-seven cases of the former and ten of the latter, and ten in which both sides are symmetrically enlarged. There are five cases of atrophy of both structures.

The vasa deferentia are comparatively larger in embryonic life than in specimens after birth. They widen out into the ampullæ in the region of the seminal vesicles and at that point there are observed a number of definite evaginations from the lumina into the solid walls which are lined with mucous membrane similar to that of the vasa deferentia themselves. These evaginations are only found after the period of adolescence. The mucosa of the vasa deferentia is made up in part of simple ciliated columnar epithelium and in part of stratified ciliated columnar cells with two rows of nuclei. The cilia are frequently absent. In the ampulla of the vas the epithelium is for the most part simple columnar in type and the cells often contain granules of yellow pigment.

The course of the ejaculatory ducts has already been described. They are lined as a rule by a single layer of columnar cells, although the mucosa is often folded and the cells are frequently arranged in two or three layers. Their walls are composed of smooth muscle and connective tissue circularly arranged, as Porosz described, but the walls become exceedingly frail in the region of the verumontanum so that any sphincteric action must be very slight. The main barrier against ascending infection seems to be the thin lappet of mucosa which is left above each orifice of the ducts as they enter the urethra obliquely on the lateral walls of the verumontanum. When these valve-like orifices become diseased, as in chronic posterior urethritis, they become indurated and are often held open, thus greatly increasing the danger of ascending infection and resulting epididymitis.

The utriculus prostaticus in old-age specimens is longer than in those of preceding periods, its average length being 0.89 cm. In later embryonic specimens as well as in the adult there are two types found. The most common is that which is contained within the tip or upper end of the verumontanum. The other extends to the base of the prostate. In this series there is one embryonic specimen which has a very small atrophied tube extending between the vasa deferentia and connecting with a thick-walled utricle which is found at the base of the prostate. This vestigial organ is absent in one case, the region usually occupied by it being filled by two tubules with many branches which enter the urethra separately. Its orifice is unprotected and, occurring as it does on the summit of the verumontanum in the midline and with its many tubules and branches contained within its wall, seems

to offer a splendid site for a stubborn infection, a fact which is borne out by clinical experience. We have in no instance found an ejaculatory duct opening into the utricle and Dr. George S. Huntington [16] asserts that he has never found the condition existing in the lower animals. Its mucosa is composed of stratified transitional epithelium and is usually much folded. The glands contained within its walls which are composed of compactly arranged smooth muscle and connective-tissue fibres are also lined with stratified epithelium.

The verumontanum is composed of tissue derived from the ejaculatory ducts and utricle which in their development push the floor of the urethra up into a mound. The length of that portion of the urethra between the vesical orifice and the upper end of the verumontanum increases quite markedly in the old-age period. During the second decade this distance measures 1.2 cm. It remains practically the same during the third and fourth decades, in the fifth decade it increases to 1.55 cm. Between fifty and sixty years of age this portion of the urethra increases to 1.75 cm. and in the old-age period measures 1.85 cm. Histologically the verumontanum is very interesting, as most of the structures entering the prostatic portion of the urethra pass through its substance, including a large majority of the prostatic ducts. By the use of Van Giesen's stain it is noted that the main portion of the stroma is made up of connective-tissue fibres, although there is some smooth muscle besides that which surrounds the ducts of prostatic tubules, the ejaculatory ducts and utriculus prostaticus.

The upper end of the verumontanum is usually quite high and arises abruptly from the floor of the urethra, while the lower end tapers down and some tissue spreads out in one or two bands on each side while fibres become lost in the tissues of the urethral wall. In one interesting case [23] these laterally disposed bands became hypertrophied and completely blocked the urethra except at one small area forming a diaphragm-like obstruction.

A group of tubules occurs in the wall of the urethra in the region of the apex of the prostate which has been termed the apex group. They are found in every specimen older than seven and one-half months intra-uterine. The largest number, twenty-six, is noted in a specimen aged four years. In older specimens they are not so numerous. The average is fifteen for all specimens studied.

Histologically they consist of small tubules, sometimes simple, but in most of the older specimens they have two or three branches. They are very delicate in architecture, not being surrounded by a definite muscle or connective-tissue envelope. They extend for some distance into

the walls of the urethra. Their lumina are small but fairly regular in outline. The mucosa is not folded. It is composed of one layer of small columnar epithelial cells. They are most numerous at the apex of the prostate and just below that point, but disappear from the urethral mucosa lower down in the membranous urethra.

Nerves.—The prostate is richly supplied with nerves and contains ganglian nodes, ganglion cells, and numerous end organs. They are derived from the inferior hypogastric plexus of the sympathetic system. A delicate plexus of nerve-fibres communicates between the seminal vesicles and prostate. Fibres from the anterior roots of the third and fourth sacral nerves are present. It is a well-known fact clinically that pathological conditions of the prostate are accompanied by very severe disturbances of various sorts. The most common of these are the referred pains which may occur in the small of the back, in or about the rectum, or down the legs. Timofeew in his very complete study has described a complicated system of nerve-fibres and endings which assists greatly in understanding this feature of the anatomy of the prostate. Von Planer described numerous nerve-endings situated in the superficial layer of the mucous membrane of the prostatic urethra. Timofeew describes a wide-meshed plexus of medullated fibres within the deeper layers of the capsule. Fine non-medullated fibrillæ pass through the prostate from the plexus and, branching freely, end between the epithelial cells. Other branches form tuft-like end bodies and still others encapsulated end organs. Some of these resemble Pacinian corpuscles with two fibres each, one of which is thick and enters as a naked axis cylinder and ends in the opposite pole as a pointed or knoblike structure; the other is thin, loses its medullary sheath, forms a finely divided fibrillary web and surrounds the axis cylinder of the first fibre as a loose tunic, but does not come in contact with it. He describes another nerve-ending as a single fibre more or less branching in all stages of transition from the simplest cylindrical form up to multiple branching forms besides the usual Pacinian corpuscles. Besides the sensory fibres he mentions the existence of many others which are apparently secretory, as they resemble similar fibres in other glandular structures. Timofeew describes both motor and sensory end structures on the fibres of Henle's muscle (striated). They are at first medullated and terminate as non-medullated fibres. The nerves of the smooth muscle-fibres are non-medullated. They form between the muscular layer thick plexuses of varicose fibrillæ which send out numerous branches.

The arteries of the prostate are derived from the internal pudic,

middle hemorrhoidal and chiefly from the inferior vesical. Branches of these vessels coursing in the capsule divide and enter the gland in the interlobular septa and dividing further send capillaries to nourish the individual branches.

The veins collect the blood from the capillaries just described and pass out to the lateral and anterior portions of the prostatic capsule, where they become quite large as a rule and intercommunicate very freely, forming the plexus of Santorini which receives the dorsal veins of the penis and is often the seat of phleboliths. This plexus also communicates with veins from the bladder, seminal vesicles, and rectum and is continued as the prostatovesical plexus to the internal iliac veins. There are exceedingly few veins found in the capsule of the posterior surface of the prostate, some of the veins collecting blood from the para-urethral region communicate with the vessels of the trigonum vesicæ.

The lymphatics begin as a network around the acini of the gland. They pass outerward and form a second plexus beneath the capsule. Here collecting tubules arise, several of which pass from the posterior part of the gland. One trunk passes to the external iliac gland, one to the internal iliac gland, and several end in the lateral sacral glands and glands of the sacral promontory. An anterior trunk is joined by lymphatics from the membranous and prostatic urethra and passes to a gland on the internal pudic artery.

In conclusion I wish to express my thanks to Dr. Hugh H. Young of the Brady Urological Institute, Johns Hopkins Hospital, Drs. Charles Norris and Morgan Vance of the Pathological Department, Bellevue Hospital, and Dr. J. Bentley Squier, Jr., of the Post-Graduate Hospital, for many favors granted in connection with this research.

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GIANT-CELL TUMORS OF THE TENDON SHEATHS

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I wish to report the following three cases of giant-cell tumors of the tendon sheaths; the first the writer was fortunate to see himself, the second was a patient of Dr. Wm. Stone, who has kindly given his permission to include it here, and the third was seen by Drs. C. E. Farr and L. A. Wing in the Out-patient Department of the New York Hospital.

Case I.—E. H., a school girl of twelve years of age, applied at the Out-patient Department of the New York Hospital for a swelling at the base of the little finger of the left hand. She had noticed this for the last three or four months, in which time it had not grown larger as far as she knew. She did not remember ever having injured herself on this hand and could not account for the swelling.

The patient, who is a healthy, strong-looking girl of average build, has on the base of the flexor surface of the little finger on the left hand a hard, round, freely-movable mass about one centimetre in diameter, it is not attached to the overlying skin or to the tendons which seem to lie under it.

A vertical incision about one inch long was made over the mass and carried down through the subcutaneous tissue, whereupon the tumor literally "popped" out, not being attached, except for a thread-like pedicle at its base. It appeared to lie directly on the tendon without any attachment to it. There was very little bleeding and the tumor seemed rather avascular. On examination it resembled a piece of *maron glacé;* it was yellowish-brown in color with a smooth surface. On its inferior surface was a deep groove in which the tendon had lain. On section it cut with cartilaginous hardness, the cut surface being smooth and uniform in appearance.

The pathological report made by Dr. W. J. Elser, pathologist to the New York Hospital, was as follows:

The specimen consists of a small tumor, the size of a bean, removed from the flexor surface of the little finger. Tumor is sharply circumscribed and was said to be freely movable.

FIG. 1.—Giant-cell tumor of tendon sheath (Case I), at the base of the flexor surface of the little finger.

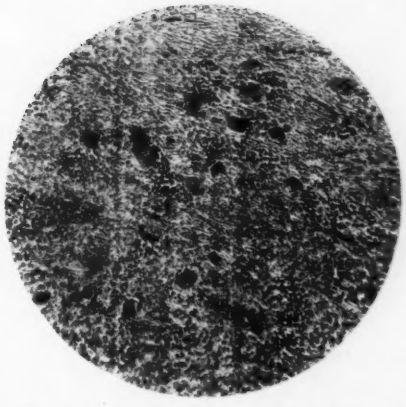

FIG. 2.—Microscopic photograph of the tumor of Case I, showing the numerous giant-cells with large number of nuclei.

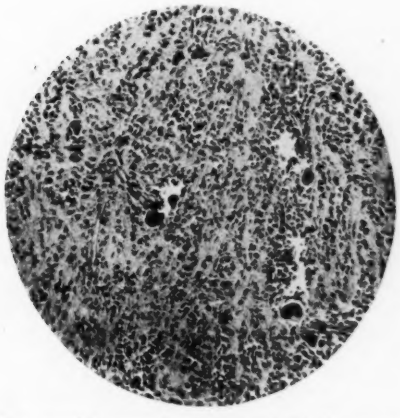

FIG. 3.—Microscopic photograph of the tumor of Case II, showing cellular structure.

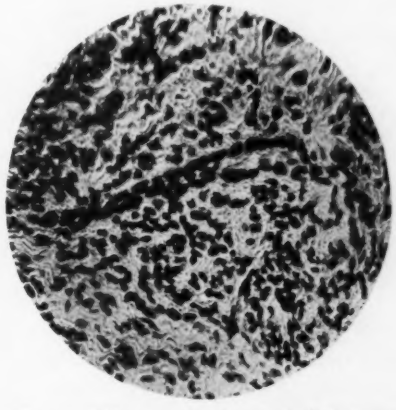

FIG. 4.—Microscopic photograph of the tumor of Case III, showing a blood-vessel with apparent proliferation of its endothelial cells.

Microscopical examination presents a picture closely resembling that of a so-called epulis. These tumors pass under the name of myeloid endothelioma. This name, however, is based upon a theory which has not definitely been established.

CASE II.—Mr. G., forty-six years old, had pulmonary tuberculosis when thirty-two years of age, from which he apparently recovered. Since this time he has been engaged in active work in the city; he has suffered a good deal from indigestion and has had several attacks of "bronchitis." He first noticed the present trouble three years ago when he sprained his ankle playing golf. Since that time the swelling, a "small lump," has slowly increased in size and has only caused discomfort when irritated by his shoes. A second swelling close to the first appeared suddenly a few months before he consulted Dr. Stone.

On examination, a bilobed, tense, cystic-like mass was found at the base of the first and second metatarsal bones on the dorsum of the foot; there were no signs of inflammation and the mass did not appear to be attached to its surrounding structures.

Under a general anæsthetic the mass was easily excised and proved to be a bilobular tumor which was situated between the superficial and deep tendons of the first toe, the lobulations being caused by one tendon passing over and the other under the mass.

The patient recovered without any difficulty but died two years later from a recurrence of his tuberculosis; up to the time of his death there had been no recurrence of the growth.

Dr. James Ewing, of Cornell University Medical College, reported the tumor to be one of the so-called giant-celled sarcomas.

CASE III.—The patient applied at the Out-patient Department of the New York Hospital, complaining of a swelling on the finger. M. C., female, thirty-eight years of age and of French birth, had for 18 months noticed a small swelling on the dorsal surface of the distal phalanx of the left index finger. She did not remember ever injuring this finger. The swelling had grown slowly until now it was about the size of a pea. On examination a small swelling was found on the dorsum of the distal phalanx of the left index finger, it was fixed to the deeper structures, the skin, however, being freely movable over it; it was slightly sensitive on pressure. Through a small incision the tumor was easily enucleated.

The pathological report by Dr. W. J. Elser was as follows:

Specimen consists of a small piece of tissue removed from dorsum of the distal phalanx of the left forefinger. This is the size of a bean. Firm in texture with appearance of fibrous tissue.

Microscopical examination shows a cellular growth, cells resembling

in some respects those found in endothelioma, in places there is a fusion of cells leading to the formation of somewhat indefinite giant-cells. Further sections made from this tumor show genuine giant-cells.

Though giant-cell tumors of the tendon sheaths are not particularly rare, little has appeared in English literature on this subject and nothing more than mention of them can be found in any of the American text-books. The French on the contrary have written many papers on this subject and the Germans are not far behind them. The literature extends back some sixty-two years when Chassaignac wrote his paper entitled "Tumeur des gaines tendineuses," which was soon followed by articles by Czerny, Billroth and others who classified them among the giant-celled sarcomas. In 1891, Haurtaux named them myelomas because of the similarity of their histology to the myeloid tumors of bone; since then many other names have been affixed, among which may be mentioned "myeloid endothelioma" (Bellamy), "hämosiderinführendes Sarcoma gigantocellulare Xanthomatodes der Sehnenscheider und Aponurosen" (Spiess), and "granulomata" (Fleissig).

From the fact that little or nothing is said about giant-cell tumors of tendon sheaths in text-books on pathology and surgery, and comparatively little can be found in medical literature, it may be supposed that these tumors are rather rare. On the contrary, they appear to be fairly common; among 71 sarcomas of tendon sheaths reported by Rosenthal 45 were of the giant-cell variety, and Tourneux collected 54 of the latter type in the examination of 93 sarcomas. In this country Bloodgood appears to have seen a number of cases.

These tumors make their appearance most frequently during the second, third and fourth decades of life, though reports of cases as early as the ninth (Menciere) and as late as the eighty-second year (Reverdine) have been made. However, in the vast majority of instances they appear in the period between the twentieth and fortieth years. They are found more often in men than in woman, Spiess reporting them 24 times in the former and but 19 times in the latter. As to occupation 50 per cent. are found in those engaged in manual labor.

The site of the lesion may be either the hands or the feet, but is found most often in the former; the commonest location being in the fingers, though at times it may be found in the palms of the hand. The right hand is affected twice as often as the left and the flexor surface is almost always the seat of the trouble, this surface seems to be the location in about 80 per cent. of the cases (Spiess). In the

foot the most common site is over the peroneal tendons near the external malleolus.

Traumatism is said to bear an intimate relationship to the development of these growths; this, however, is a disputed point. A history of sudden trauma may be obtained or there may be an indefinite history of a slight, oft-repeated irritation. This, by some, is thought to be deceptive, for, as in growths in other parts of the body, a history of trauma may be obtained in almost every case and is misleading, as any previous knock or scratch is remembered by an individual and ascribed by him as the cause of any growth which may appear later. Tourneux remarks on the apparent frequency of preceding trauma, but does not believe that we have enough direct evidence to ascribe it as a definite cause of the condition. It may be said here, that in the three cases reported in this communication no history of trauma could be obtained. Additional evidence in favor of it as an etiological factor may be found in the frequent appearance of the neoplasms in men, especially those engaged in manual labor, its choice of the flexor surface of the fingers and hand and its frequent appearance in the right hand.

The onset of these neoplasms is insidious, their growth is slow; because of the lack of subjective symptoms, the "lump" is often overlooked until it has attained a considerable size. Their duration may be from a few months to ten or twelve years, the average being three or four years. The swelling is never very large, varying from a few millimetres to several centimetres in diameter. They are painless, except when irritated, and do not interfere with the functions of the affected parts.

On examination they appear as hard, round, smooth, painless swellings which at times may be lobulated. The skin is freely movable over them and though they may be firmly fixed by the tendon sheath or fascia they do not often interfere with the movements of the tendons. At operation they are easily shelled out, without producing damage to the surrounding structures.

The shape and size of these tumors depend to a great extent upon the resistance of the surrounding structures; the strong fascia of the hand and foot bind them firmly down, limiting their size, and deep sulci are often produced by the tendons upon which they have been held, giving them at times a lobulated appearance.

The tumor when removed is found to be well encapsulated and usually some direct connection with the tendon sheath can be demonstrated. In size they vary from a few millimetres to several centimetres; never attaining a very large size because of the denseness of

the surrounding tissues. Their surface is smooth and their color varies from a dark reddish-brown to a light yellow; in consistency they are hard and often cut with almost cartilaginous resistance; the cut surface is smooth and glistening and gives one the idea of cartilage.

The histological picture is quite characteristic, it consists of a connective-tissue stroma containing numerous multinuclear giant-cells. The stroma is usually composed of a matured type of fibrous connective tissue, though at times it may be cellular; if of the latter variety the cells may be round, spindle or of the mixed cell types; however, of whatever variety they may be the picture is that of a slowly growing tissue. The cells are small, regular in outline and stain evenly; their nuclei stain uniformly with basic dyes, are regular in shape and outline and do not show any increase over the normal in mitotic figures. The giant-cells may vary considerably in number, usually they are numerous; they are round, their cytoplasm stains uniformly and the nuclei are grouped centrally, giving the appearance of a whorl, quite different from the peripherally distributed nuclei of foreign body giant-cell as typified by those of the tubercle. Their nuclei resemble those described for the stroma cells, they may vary from several to a hundred or more to a cell. Adami considers these giant-cells to be of a matured type, identical with the myeloplaxes found in the bone-marrow. The tissue is fairly vascular; at times red blood-cells or blood pigment may be found infiltrating between the fibres of the stroma.

Certain lipochrome substances resembling the fatty body present in xanthoma cells are at times found and may be the cause of the yellow color of the tumor.

Concerning this pigment, little definite information is known. Under normal conditions lipochrome pigment, in considerable abundance, is found in the corpora lutea in the form of lutein and the yellow color of normal fat is said to be more or less due to this substance.

In addition to this it is also found in ganglion cells during advancing life, and some authors believe that muscle undergoing brown atrophy contains this substance. The fatty bodies found in the cells of xanthomas are apparently true lipochromes and some authors state that the greenish pigment found in chloromas is of the same substance. The lipochromes in the cells of giant-cell tumors resemble those of xanthoma cells; however, we do not know the origin of this substance in these tumors. It seems quite probable that it may be of the nature of a degenerative process; to substantiate this view we may again mention the fact of the presence of this material in certain of the nerve cells of individuals of advancing age and the degenerative changes in

muscles, which are said to contain lipochromes. Adami, speaking of xanthomas, says, "Some observers attribute the growth to a preceding inflammation, while others (Ziegler) regard it as a lipomatous lymphangioma or endothelioma." Pollitzer asserts that xanthomas of the eyelid are not neoplasms but are due to the degeneration of preexisting embryonal, misplaced muscle tissue. It appears to us that these facts would tend to strengthen the view of the degenerative origin of this yellow pigment.

The histological picture which has been described resembles more that of the giant-cell epulis than any other giant-cell tumor that we know of; however, it does not, like the epulis, develop from the periosteum as in no case has a definite connection with that layer been demonstrated. Certain other characteristics of behavior, in common with the epulis, are present; if entirely removed it does not recur and it does not metastasize. It is true that in a few cases reports of metastases have been made, but we feel that these cases had either undergone sarcomatous changes or that the tumor in the first place was of a malignant variety of mixed-cell sarcoma. The general opinion seems to be that these tumors do not recur after removal and that they do not metastasize.

The question now arises as to the nature of these growths and by what name they should be called. To answer this question we would have to take up the discussion of giant-cell tumors in general. We, however, do not feel that the scope of this paper calls for such a course and therefore shall only attempt to state some of the principal views on the subject.

Among the modern writers who still adhere to the name of giant-cell sarcoma or myeloid sarcoma for this type of growth may be mentioned Tourneux, Spiess and Stewart.

Tourneux, in an article on sarcomas of the tendon sheaths, states that the giant-cell tumors may recur after removal and therefore cannot be considered as benign growths. Spiess in his study of 48 cases of giant-cell tumors of tendon sheaths comes to the conclusion that there are several varieties of these growths, that they are benign and should not recur after removal. Stewart, in a recent article in the *Lancet,* entitled Observations on Myeloid Sarcomas, divides giant-cell tumors into two classes, myeloid sarcomas and malignant giant-cell sarcomas; he believes that the former are only locally malignant, that their histological picture is that of a benign tumor and that if properly removed recurrence will not take place. This is in contrast to the malignant giant-cell sarcoma, the histological picture of which shows

active signs of proliferation. We believe that the term "sarcoma" should be reserved for new growths of mesenchymal origin which by their life history and histological picture satisfy the postulate of a malignant tumor. The neoplasm under consideration in this article certainly does not do this; it is slow in growth, does not recur after proper removal, does not produce metastases, and the microscopical picture is not one of active proliferation. To use the term "sarcoma" for such a tumor loses the significance for the name and also brings to one's mind the demand for radical treatment which in this case is entirely uncalled for.

Of the writers who use the name myeloma, believing that these growths are developed from cells which have to do with osteogenesis, may be mentioned Bellamy, Adami and Matthews. These authors consider the giant-cells to be similar to the myeloplaxes of bone. Bellamy claims to have seen proliferation of the endothelial cells of the smaller blood-vessels in tumors of the tendon sheaths and believes that the giant-cells may be formed in this way; he has therefore called the tumor a myeloendothelioma. We cannot find that his views as to endothelial proliferation have been confirmed by others, but in our third case, the microscopic sections showed vessels, in which the endothelial cells were markedly increased. The nuclei of these cells were very similar to those of the stroma cells. Because of this finding we cannot deny the endothelial origin of these tumors, nor do we feel, that in this one case, we have enough evidence to affirm it. If giant-cell tumors of tendon sheaths have their origin from myelopaxes we would expect them at some time to be in direct communication with bone; there is, however, no proof that this occurs, the only suggestion being the fact that the commonest location of the growth is in the tendon sheaths which are in close proximity with bony surface, as found in the hands and feet.

Fleissig, because of the lack of polymorphism, polychromasia, destructive invasion of the surrounding tissue and mitosis, believes that these growths can no longer be classed among the neoplasma but must be placed with the granulomata. In this country Mallory has contended that the giant-cells in this type of growth are nothing more than foreign-body cells and that the tumor containing them should not be named from the presence of these cells but from the character of those of the stroma. This author goes so far as to call the osteoclasts of normal bone foreign-body giant-cells and that their presence signifies the erosion of bone. We cannot see that these writers have proved the inflammatory origin of these growths nor do we believe that the

giant-cells of these tumors resemble in any way those due to chronic irritation.

The microscopic structure of these tumors is, to be sure, that of cellular connective-tissue neoplasms, resembling sarcoma, but the behavior, as we have seen, is that of a simple benign growth. As we have before said, to call it a sarcoma is very misleading and makes one think of radical treatment which, as we have shown, is entirely uncalled for. To use the name endothelioma is unsatisfactory, in view of the fact that the nature of the cells comprising the growth has not been established. The term "myeloid" suggests some connection with the medullary cavity of bone, which has not been proven. Until further is known of the origin of these growths, we would suggest, for the lack of a better name, that they be called "giant-cell sarcoid tumors of the tendon sheaths." We agree with Bloodgood that the term "giant-cell" is well established and should not be dropped. And in view of the fact that the histological picture resembles that of a sarcoma, it has been suggested that we use the term "sarcoid" (from σάρξ, flesh, and εἶδος, form).

The treatment of these tumors should be of conservative character. They being well encapsulated, enucleation is easily performed through a small incision without disturbing neighboring structures.

In conclusion I wish to thank Drs. Stone, Farr and Wing for allowing me to use their cases, and Dr. James Ewing and Dr. W. J. Elser for their help to me while writing this paper.

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FASCIA TRANSPLANTATION IN THE TREATMENT OF OLD FRACTURES OF THE PATELLA

By D. B. Phemister, M.D.
of Chicago, Ill.
(From the Department of Surgery, Rush Medical College)

In cases of fracture of the patella with wide separation of the fragments, which have been allowed to heal in this position, an elliptical defect in the extension apparatus of the knee, running transversely across, is the condition which remains. The fracture surfaces of the fragments are rounded or pointed by new bone formation from the ends. The joint cavity extends forward, between and in front of the fragments, is limited by the subcutaneous tissue and lined by a newly formed synovial membrane. The transverse bands about the upper fragment contract and bind it firmly against the shaft of the femur. This distorts and may completely obliterate the upper recessus of the joint. The quadriceps extensor gradually contracts and atrophies. Villous arthritis or chronic hydrops of the joint may develop.

In such cases the patients get around with great difficulty, walking carefully and with a limp. The knee frequently gives way, causing the patient to stumble or fall. Stairs have to be ascended or descended one step at a time. When lying the heel cannot be lifted from the bed and extension is possible only to a very limited degree.

The method of repair of the extension apparatus must vary according to the amount of separation and contracture. The upper fragment should be loosened and whenever possible the two fragments as well as the torn capsule should be brought into apposition, where, after freshening the edges, they are sutured. When after lateral incision and traction, apposition has still been impossible, various plastic procedures have been resorted to for closing the remaining defect.

The upper fragment has been displaced downward in one of two ways. Macewen made a large V-shaped incision in the quadriceps, pulled the fragment downward and closed the cut in the shape of a Y. The method has been successfully used in a number of cases, but Quenu and Wrede object to it because of the weakening and adhesions of the quadriceps which interfere with flexion. Lister operated in two stages, suturing the fragments as close together as possible. At the first operation and completing the approximation after a number of weeks

this plan should be avoided if it is found possible to make any kind of a satisfactory repair in one stage.

The lower fragment was shifted upward by von Bergmann to meet the upper one. The tibial spine with its tibial patellar tendon was detached and displaced upward where it was attached to the upper end of the tibia. The method has been abandoned because the distance gained is frequently insufficient to close the defect and it is difficult to attach the tuberosity in its new position.

Plastic flaps have been turned into the defect from the surrounding tissues. The soft parts were first used in this way by Ferraresi who turned down a flap consisting of fascia and a layer of the underlying quadriceps femoris muscle. The patellar fragments may even be excised in such cases with satisfactory results. Shanz shifted the detached lower end of the sartorius muscle into the defect, suturing it to the quadriceps above and tibial patellar tendon below. Julius Wolff and Rosenberger employed bony and fibrous flaps, reflected from the anterior portions of the patella fragments, but they affect only a feeble and imperfect closure of the defect.

In the case herewith reported after the greatest possible apposition of the fragments had been accomplished there still remained a defect of one inch. This defect was then bridged over by a free transplantation of the fascia lata. The details of the case are as follows:

> Mr. R. L., age thirty, entered the Presbyterian Hospital, December 6, 1914, with the following history: March 19, 1914, he jumped from a wagon, lighting upon both feet. He experienced severe pain in the left knee which gave way and threw him to the ground. When assisted to his feet he was unable to walk or to extend the limb. A physician diagnosed fracture of the patella and applied a posterior splint which was worn for eight weeks. At the end of that time he was unable to walk without a crutch because of flexion of the knee when the body weight was thrown upon it. A short posterior splint was worn for two months, since which time he has gotten around with a cane. Improvement has been slight. The knee frequently flexes unexpectedly, causing him to fall. Stairs are ascended and descended with great difficulty and lifting is impossible so that he has been unable to resume work as an expressman.
>
> Examination shows a muscular young man who walks with a marked limp in the left leg. There is moderate swelling of the left knee which extends a short distance above the normal level of the joint. The quadriceps muscle is somewhat atrophied. He is unable to extend the leg or to lift the heel from the bed when the

thigh is flexed. Palpation shows the patella separated into an upper and a lower fragment and three fingers can be inserted into the intervening space with the limb in extension (Fig. 1).

Operation (December 7, 1914).—Ether anæsthesia. A longitudinal incision seven inches in length was made over the knee, exposing the lower part of the quadriceps muscle, the two patellar fragments and the tibiopatellar tendon. There was non-union between the widely separated upper and lower margins of the tear, leaving a transverse elliptical opening into the knee-joint. The joint cavity extended anteriorly between and in front of the patellar fragments into the subcutaneous tissue. It was lined by a newly-formed synovial membrane. The fracture surface of the upper fragment was rounded and that of the lower fragment pointed by new bone formation. The upper fragment was firmly fixed above the condyles of the femur by the contracted lateral ligaments. They were incised and extensive downward traction made on the fragment. It was impossible to bring the fragments closer than one inch of each other. They were held in this position by an encircling suture of heavy silk. The tears in the ligaments were sutured with catgut, but near the patella on either side they could not be closed (Fig. 2). To bridge over the remaining defect without weakening the surrounding parts a free transplant was taken from the fascia lata of the middle of the thigh. It was sutured above to the quadriceps, below to the tibiopatellar tendon, and at the sides to the lateral ligaments of the joint (Fig. 3). Aseptic wound healing occurred. A plaster cast was worn for four weeks, after which a posterior splint was applied and the patient allowed to walk. Since the eighth week he has been using the limb without any support. Extension was almost complete at that time, but flexion was limited to 45 degrees. Fig. 4 shows the relation of the fragments, and Fig. 5 the amount of extension at the end of six months. At present, eight months after the operation, the limb can be flexed beyond 90 degrees and is practically as strong as before the injury. He has been working for the past three months.

The advantage of a free fascial transplant where the fragments cannot be approximated is that it affords a stronger closure of the defect than can be obtained by taking flaps from the weaker surrounding fascia, and in no way weakens any of the normal portions of the extension apparatus. The transplant should be made wide enough to cover the defect in the lateral ligaments of the patella as well as that between the fragments.

FIG. 1.—Before operation.

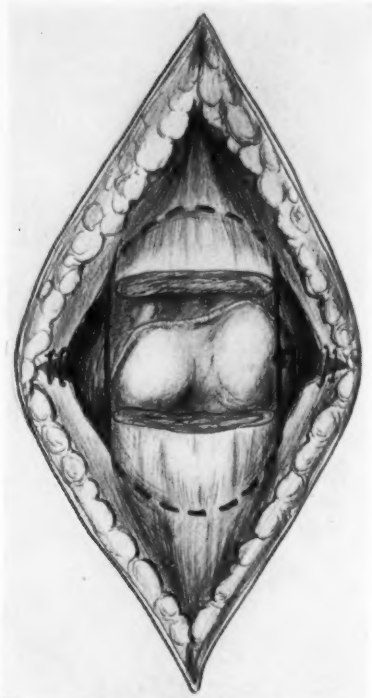

FIG. 2.—Fragments encircled by silk suture and capsule sutured laterally.

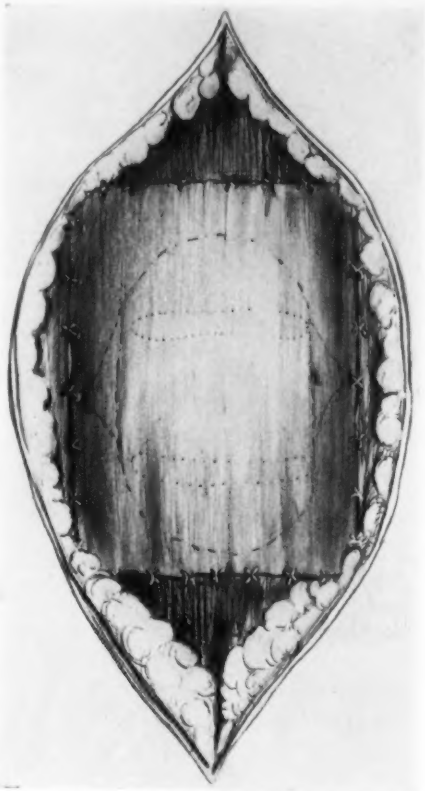

FIG. 3.—Fascial transplant sutured in place.

FIG. 4.—Six months after operation.

FIG. 5.—Amount of extension six months after operation.

DECOMPRESSION UNDER LOCAL ANÆSTHESIA

By Herbert P. Cole, M.D.
of Mobile, Alabama

Having occasion recently to perform decompression upon an epileptic with a dubious prognosis from the stand-point of cure, local anæsthesia was adopted as the procedure subjecting the patient to the least risks.

In so far as we are aware a complete decompression under local anæsthesia has not been reported before in this country, this together with the ease with which the technic was performed without untoward results prompts us to present our experience to the profession.

The patient, referred by Dr. Seale Harris of Birmingham, Alabama, a white male, aged thirty-three, gave a history of injury to the skull years before admission to our clinic. The location of injury was indefinite, though the onset of the typical epileptic convulsions definitely followed the injury. There being no evidence of a focal nature, decompression was advised only because years of medical treatment had not availed.

The prognosis being explained to the patient as offering at best only a possibility of improvement and a meagre probability for cure was, nevertheless, eagerly accepted. Believing that a decompression performed upon the patient in a conscious state might disclose the focal point more readily, we determined upon the use of local anæsthesia as the method offering the least operative risk.

Operation (April 29, 1915).—Preliminary scopolamine and morphine. After the usual preparation a tourniquet was placed about the head with a comfortably firm pressure. After the method of Braun about 60 c.c. of a one per cent. novocaine-adrenalin solution was injected at seven points over the temporal region above the tourniquet (see Fig. 1). The solution was injected in all the layers of the scalp down to the periosteum and the points of injection were connected both superficially and in the deep tissues, thus providing a seven-sided area of anæsthesia.

An osteoplastic flap decompression was then performed with no discomfort to the patient. We noted with considerable surprise the absolute absence of pain in the periosteum and upon trephining the bone and using the Gigli saw and rongeur. A rather large dural flap was made, without sensation to the patient,

the pia, beyond appearing rather œdematous, was apparently normal. Pressure stimuli upon the anterior Rolandic area elicited little response and we believe the infiltrating fluid on the scalp tended to reduce pressure stimuli—a possible objection to the use of local anæsthesia in some cases. Shortly after beginning our pressure stimuli the patient's pulse rapidly rose to 150 per minute, the arteries became engorged, and the patient passed through a typical epileptic seizure of several minutes' duration. There were no focal signs indicating that our stimuli produced the attack. He was controlled by force, and at the end of the seizure the operation was completed by passing the dural flap out beneath the bone into the temporal muscle. The osteoplastic flap was replaced and sutured. The patient returned to the ward with a pulse of 120, in excellent spirits, and complained of no pain.

Post-operative.—The patient made an uninterrupted recovery from the operation, suffered very little post-operative pain and presented no urinary changes. He described his experience as not an unpleasant one and complained that the only discomfort was from the pressure of the tourniquet. He was conscious of most of the remarks addressed to him and recalled having a lapse and the sensation of having had an epileptic seizure.

This patient has had a diminution in the number and severity of his attacks.

CONCLUSION.—Cerebral cases presenting grave or uncertain prognoses do not warrant serious operative risks. Local anæsthesia permits of extensive intracranial procedures. It will also doubtless do much to clear up the localization of the motor and sensory areas by permitting extensive observations upon the conscious patient.

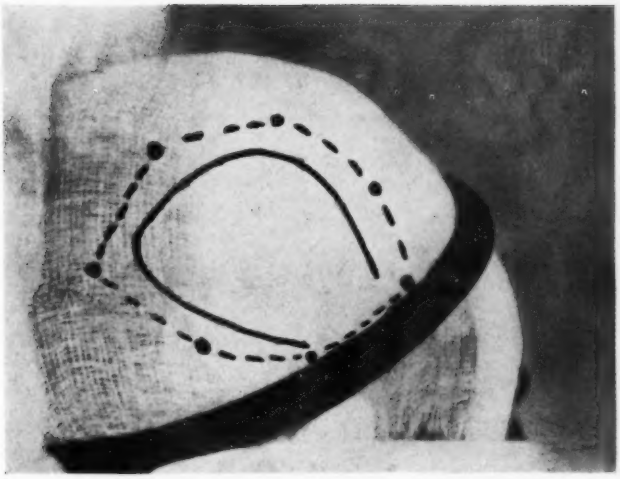

FIG. 1.—Dots mark points of deep local anæsthesia injection. Dotted lines mark lines of superficial and deep communicating infiltration. Straight line marks line of incision.

FIG. 2.—Actual photograph of decompression under local anæsthesia.

THE ACTION OF RADIUM ON TRANSPLANTED TUMORS OF ANIMALS

By Francis Carter Wood, M.D.

and

Frederick Prime, Jr., M.D.

of New York

(From Columbia University, George Crocker Special Research Fund)

During the last few years there has been much discussion as to the therapeutic use of radium in the treatment of malignant growths, and opinions as to its value, based chiefly on clinical reports, have differed greatly. It has, therefore, seemed important that the question of the efficiency of radium as a destructive agent for tumor cells should be settled as soon as possible, the more especially, perhaps, as a great deal of newspaper notoriety has of late been given to this method of treatment of malignant growths in man.

Whether the beta or the gamma rays are the more efficient in treating tumors, or whether both should be employed, are questions which are still undecided. So much, however, is certain: that unless the beta rays can largely be removed by filtration, radium cannot be used to treat neoplasms lying even a few centimetres beneath the skin, because the intervening normal structures will be destroyed by these rays before the growth itself is influenced.

No extensive quantitative studies of the lethal effect of radium on tumor cells have yet been made, though Wedd and Russ,[1] and Wedd and Chambers[2] have published the results of experiments on a few animals. Pentimalli[3] could find no morphological changes in mouse tumors exposed for a number of hours and then examined microscopically; it would have been extraordinary if he had. v. Wassermann[4] thought that two hours' exposure to 50 mgm. of mesothorium screen with 1.5 mm. of brass destroyed the genoceptors, so that the cells remained alive for a few days only to die later because of interference with mitotic division. As has been shown by Wood and Prime,[5] however, his experiments were too few, and the methods used too unsatisfactory, either to prove his theories or to give information as to the lethal dose of mesothorium, which is presumably the same as that

of an equivalent quantity of radium.* Thus in most reports of work done with human or animal tumors, the quantity of the radium element used, the screen employed, the distance of the tissue from the radium, and the time of exposure have not been accurately stated. As these factors furnish the only scientific basis for computing the efficiency of radio-active substances, it was decided to carry out a line of experiments on the biological action of radium, using animal tumors as an index of the lethal effect. A few of these experiments are here reported.

The method was as follows: Rat and mouse tumors of various types were used, among them the Ehrlich spindle-cell mouse sarcoma, the Flexner-Jobling rat carcinoma, and mouse carcinomata No. 11 and No. 180 of the Crocker Fund series. These were treated either after removal from the host or *in situ*. In the former method a portion of the tumor to be used was cut into small pieces of uniform size, and these were moistened with Ringer's solution, put into hollow slides, covered with a thin cover-glass, sealed with paraffin, and exposed to the tubes of radium. The strictest asepsis was observed in all these operations. Four tubes of radium, containing respectively 83, 20, 17, and 10 mgm. of element were used, singly and in combinations giving 100 mgm. and 30 mgm. The dimensions of the tubes were as follows:

Quantity	Length	Diameter
10 mgm.	17. mm.	3.5 mm.
17 mgm.	14.5 mm.	2.7 mm.
20 mgm.	19.4 mm.	3.4 mm.
83 mgm.	28.7 mm.	3.4 mm.

Brass was uniformly employed as a filter, in thin or thick sheets, as required to pass or eliminate the hard beta rays. The tissue was placed directly beneath the cover-glass, and in most cases in contact with it, and in order to prevent all loss of vitality of the tumor cells during the more lengthy exposures, the exposed and the control tissues were kept in separate "Thermos" vessels at a temperature slightly above 0° C., comparative tests having shown that the action of the radium was not influenced by the temperature at which the growth was preserved. After exposure to the beta and gamma rays in different amounts for varying lengths of time, portions of the treated tumor, as well as untreated fragments which had been kept for controls, were inoculated into animals of the same strain.

* Mesothorium is always estimated in terms of an equivalent amount of radium, and is not sold by weight. The commercial product contains about 25 per cent. of radium.

The alpha rays were not employed in any of these experiments, as they have almost no penetrating power, cause superficial burns only, and cannot be used practically in the treatment of tumors except those of the skin. The tissue was exposed either to a mixture of beta and gamma rays or to the gamma rays alone.

The beta rays from radium are extremely complex; but, roughly, may be said to consist of soft, medium, and hard rays, as judged by their spectra and absorption coefficients in metal screens. The softer groups are absorbed by 0.4 mm. of brass, whereas the medium and hard beta rays penetrate this and have a range in the tissues of about 8 mm. A brass screen of about 1.2 mm. thickness will absorb all but a negligible fraction of the medium and hard groups.

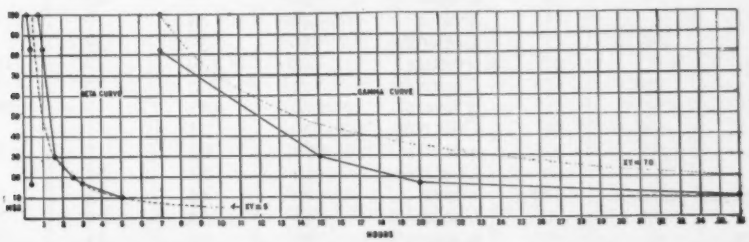

FIG. 1.—Plottings of curves of observed minimal lethal exposures on the abscissæ against milligrammes of radium on the ordinates. The first curve from the left shows the time required to kill carcinoma and sarcoma cells when the glass tubes containing the radium are unscreened. The observation includes 100 mgm., 83 mgm., and 17 mgm. The second solid curve gives the results when the glass tubes are screened with 0.4 mm. of brass. The dotted curve is that of $xy=5$. The solid curve furthest to the right gives the results with gamma rays, obtained by screening the radium tubes with 1.2 mm. of brass and 5 mm. of filter paper. The dotted line is the curve of $xy=70$. From this chart the approximate time of exposure necessary to kill all tumor cells at a given distance can be estimated for each weight of radium, or, if preferred, the time of exposure can be found on the chart, and then by following up one of the vertical lines the amount of radium required to kill the cells at the given distance can be determined.

The gamma rays are by far the most penetrating of the three varieties of rays, though 10 per cent. are absorbed by 1 cm. of tissue. They pass easily through 1.2 mm. of brass, only about 3 per cent. being absorbed. In passing through the metal screens used to remove the beta rays, the gamma rays generate soft secondary beta rays of very slight penetration, and in order to absorb these and thus use as pure gamma rays as possible, a mass of filter paper (Schleicher and Schüll, No. 575) 5 mm. thick, was placed beneath the brass. Such pure cellulose, in virtue of the low molecular weight of its constituent elements, does not appreciably absorb the gamma rays.

One large group of experiments was undertaken, in which the tumor tissue was exposed *in vitro* to radium, the radiations being filtered through 0.4 mm. of brass, a cover-glass 0.15 mm. thick, and the glass of the tube containing the radium, 0.5 mm. in thickness, a total distance of about one and one-tenth millimetres. No paper filter was used in this

case. The results, tabulated in Table I, show that 100 mgm. of radium will kill tumor cells at this distance after forty-five minutes' application, 83 mgm. after one hour, 30 mgm. after one and one-half hours, 20 mgm. after two and one-half hours, 17 mgm. after three hours, and 10 mgm. after five hours. No difference in the lethal dose on any of the various tumors used was noted.

TABLE I

Character of rays	Mgm. of radium	Time of irradiation	Number of mice		Growth of tumor	
			Inoculated	Survived	+	−
Beta and gamma..	83	30 minutes	72	61	26	35
		Controls	72	57	43	14
		45 minutes	72	61	1	60
		Controls	72	57	43	14
		1 hour	48	44	0	44
		Controls	48	36	32	4
		2 hours	144	130	0	130
		Controls	144	133	88	45
		3 hours	120	105	0	105
		Controls	120	91	87	4
		4 hours	72	65	0	65
		Controls	72	57	52	5
Beta and gamma..	17	1 hour	48	44	15	29
		Controls	48	33	20	13
		2 hours	96	91	23	68
		Controls	96	84	55	29
		3 hours	144	116	0	116
		Controls	144	107	103	4
		4 hours	72	70	0	70
		Controls	72	57	52	5

The results, when plotted with weight of radium as ordinates and time as abscissæ (Fig. 1), give a curve approximating very closely to a rectangular hyperbola, that is, to a curve representing a condition in which the product of two variables is equal to a constant. For comparison, the curve of $xy=5$ has been plotted as a broken line, and it will be noted that the fit of the two curves is very good for a biological experiment. Since the distance between the radium and the tissue was the same in each series of experiments, the only two variables were the weight of radium element and the time of exposure.

The tumor tissue which had been exposed to both beta and gamma rays for a time just too short to kill the cells, showed marked slowing in growth rate as compared to the unexposed controls, and, in several of the series, tumor cells which had been exposed did not even begin to grow until five or six weeks had elapsed; in the controls, on the contrary, nodules appeared in from seven to ten days after inoculation of the untreated tumor cells. This shows the necessity for long periods

of observation before a tumor can be considered to have been killed by radiation. Similar delayed growths have been noted in man.

If, however, the beta rays were filtered out, a great difference was noted in the time required to cause the death of tumor tissue. In order

TABLE II

Character of rays	Mgm. of radium	Time of irradiation	Number of mice		Growth of tumor	
			Inoculated	Survived	+	−
Gamma.....	100	6 hours	120	107	13	94
		Controls	120	111	110	1
		7 hours	48	46	0	46
		Controls	48	42	38	4
		8 hours	48	45	0	45
		Controls	48	47	41	6
		12 hours	96	89	0	89
		Controls	96	85	80	5
		18 hours	120	94	0	94
		Controls	120	102	100	2
Gamma.....	83	6 hours	72	62	18	44
		Controls	72	56	55	1
		7 hours	48	45	0	45
		Controls	48	45	45	0
		8 hours	48	37	0	37
		Controls	48	38	31	7
		12 hours	144	106	0	106
		Controls	144	112	104	8
		18 hours	144	118	0	118
		Controls	144	121	98	23
Gamma.....	30	6 hours	24	23	21	2
		Controls	24	21	21	0
		11 hours	96	65	3	62
		Controls	96	70	67	3
		12 hours	144	114	7	107
		Controls	144	112	104	8
		15 hours	96	65	3	62
		Controls	96	70	67	3
		18 hours	168	145	0	145
		Controls	168	145	131	14
Gamma.....	17	6 hours	72	62	55	7
		Controls	72	56	55	1
		12 hours	144	119	41	78
		Controls	144	112	104	8
		15 hours	48	47	11	36
		Controls	48	44	32	12
		18 hours	144	117	19	98
		Controls	144	121	99	22
		20 hours	24	24	0	24
		Controls	24	23	22	1

to remove the secondary beta rays as far as possible, a screen of filter paper (S. & S. No. 575) 5 mm. thick was used in addition to 1.2 mm. of brass, it being assumed on the authority of Keetman and Mayer[6] that by this filtration practically only the gamma rays would reach the exposed tissue. The distance, therefore, from the radium tube to the

tissue was about 6.9 mm. After a long series of experiments it was found that exposures of seven hours to 100 mgm. or to 83 mgm. of radium were necessary to kill the tumor cells. Thirty mgm. killed at a point between fifteen and eighteen hours, while 17 mgm. and 10 mgm. killed the tumor cells in twenty and thirty-six hours respectively (Table II). In brief, a much longer time was required when the gamma rays only were used. When the radium was filtered through 1.2 mm. of brass raised 5 mm. above the cover-glass but without filter paper, the results were about the same as when the filter paper was used, showing that the secondary beta radiations generated by the impact of the gamma rays on brass are not practically effective. The only result attending failure to employ the filter paper would be a greater or less burning of the skin. It may be said, in passing, that it is impossible to destroy a metastatic nodule of breast carcinoma in man without burning the skin to a slight degree. In animals, however, the skin is less susceptible and will stand long exposures without serious injury.

The results have been plotted graphically, and the curve $xy=70$, also, has been drawn in a broken line. In this case, the fit is nearly, though not quite, as close to the theoretical as in the curve of the combined beta and gamma action; nevertheless, the chart furnishes a means of estimating the quantity of radium element and time of exposure necessary to kill a cancer cell at any chosen distance. It must always be remembered that the action varies inversely as the square of the distance, and, as the distances plotted are respectively 1.1 mm. and 6.9 mm., the amount of time required for a given distance, say 13.8 mm., is computed as follows: The square of 6.9 is 47.6 and that of 13.8 is 190.4. These two values are in a ratio of 1:4; hence, if the distance is doubled, the exposure is quadrupled. That extremely long exposures or very large amounts of radium are required to kill cancer cells at a distance of, say, 10 cm., is evident from this.

The sharply rising curve, tending to become parallel with the vertical ordinate, shows also that when the distance between the cancer cell and the radium tube is small, but little is gained by greatly increasing the amount of radium employed. If 100 mgm. kill in one hour, 200 or 300 mgm. will take at least half an hour. It is better, therefore, if large quantities of radium are to be used, to distribute the substance about or in the tumor so that each tube acts separately, rather than to combine the whole amount in a single tube. This is the procedure which is now practised by those who use small glass or metal tubes containing radium emanations inserted into various portions of the tumor to be treated.

For the lack of sharpness in the lethal dose of gamma rays (Table II) it is impossible to offer any adequate explanation. With the beta rays, the time and dose required to kill a tumor fragment is quite definitely fixed, as has been repeatedly demonstrated in this laboratory on a great variety of tumors, and there is no appreciable difference in the results of radiation of sarcoma and of carcinoma cells. In the case of the gamma rays, on the other hand, the exact determination of a minimal lethal dose for moderate quantities of the element, say 20 mgm., is difficult. To kill every one of a series of tumor fragments requires a much longer time than to kill 80 to 95 per cent. of such fragments. As an example, when 30 mgm. element were used for six hours, the radiated fragments and controls grew in about the same proportion, while after eleven hours only 2.2 per cent. of the irradiated particles grew, though there were 72 per cent. of positives in the controls. About the same proportion occurs until, as Table II shows, the death of all the tumor cells is accomplished after an exposure of eighteen hours. As just stated, this variability in the death of tumor cells is not at present explicable. It may be that the lethal action of the gamma rays is exhibited only in groups of young cells which are undergoing or have recently undergone mitosis, for example, and that only older cells escape to grow in the tissues of the host and produce a tumor; or, again, it may be that the rays act by the direct production of toxic catabolic products (for instance, cholin, as suggested by Werner), and that the individual tumor cells contain different amounts of the lecithin from which the cholin is produced, so that only highly charged cells are injured. A third explanation may be that the generation of sufficient secondary beta rays to kill the cells depends upon the blood content of the tissue, and, hence, its iron content, as the secondary rays from iron are more penetrating than those from substances of lower molecular weight. There is, in fact, much variability in the amount of blood in different fragments of tumor. In these cases, as in exposures to the beta rays, the growth of the tumor which had received a sublethal dose was always much less rapid than was that of the control, as has been shown by Russ and Chambers (*loc. cit*), while practically no late growths followed treatment with the gamma rays, as was the case after beta ray exposures.

The periods as thus determined are somewhat longer than the time required to destroy the cells in a small skin metastasis from a carcinoma of the human female breast. One of us (Wood) has found that exposures of six to eight hours with 83 to 100 mgm. of radium, screened

with 1.2 mm. of brass and 5 mm. of filter paper, will in many instances cause permanent disappearance of these nodules. A shorter application to such metastatic nodules slows the growth but does not kill the tumor cells, while still shorter exposures or smaller quantities used under the same conditions have a stimulating effect. These observations show that the statement, made by several German experimenters (v. Wassermann, Pentimalli, etc.), that mouse carcinoma is much more resistant to radium than human neoplasms of the same type, is not wholly justifiable. Any one who has attempted to cure a primary, rapidly growing carcinoma must have been impressed with the wonderful resistance which such tissues often display toward the action of radium, though, as is well known, some other types of malignant neoplasms in man, such as the basal-cell epitheliomata, are much more easily affected.

When the excised tumor tissue was exposed *in vitro* directly to the action of the radium, with no filter except the cover-glass intervening, the cells were killed, as proved by inoculation, by 100 mgm. and 83 mgm. in ten minutes, and by 17 mgm. in twenty minutes; this experiment demonstrates the great destructive power of the softer groups of beta rays. The use of such unfiltered rays is possible in man only in treating superficial growths, where the severe burning which may result can be limited to the tumor area and, hence, be of no importance.

In the second part of the experiment, a carcinoma, No. 11, was exposed *in vivo* to the action of radium, and was then removed, and the fragments were inoculated into other animals. In these cases the animal was anæsthetized and the skin over the tumor was reflected; and then, after a small portion of the mass had been removed and put away on ice for use as a control, the tube of radium was applied to the tumor, which was protected only by a 0.4 mm. brass sheet. After the application of 83 mgm. of radium for two hours, some of the tumor tissue was removed from an area directly beneath the radium tube, and this, upon inoculation, showed some slowing in growth as compared with the control, but the cells were not killed, as is the case even after one hour *in vitro*. The constant supply of fresh nutriment to the cells by the blood, and the removal of any chemical products formed by the radium in the tissue, must account for this difference. Tissue removed from the other side of the tumor, also *directly* under the radium tube, but about 1.1 cm. distant from it, showed no slowing in growth nor delay in appearance, upon inoculation, but grew quite as well as, or even a little better than, the controls. Therefore, the gamma rays from

even so large an amount of radium as 83 mgm. of element have not sufficient power to affect tissue at a distance of 1 cm. during two hours' exposure. As 1 cm. of tissue absorbs nearly all the beta rays these would not be effective over the space mentioned. The experiment was not continued over longer periods as it is difficult to keep mice under ether anæsthesia for more than two hours.

In these, and in similar experiments not detailed here, the law of inverse squares is clearly shown. For example, if the distance of the tube from the proximal portion of the tumor is, as in the above experiment, 1.1. mm., and from the distal portion 11 mm., then the effect is not as 1 to 10 but as 1 to 100; when the conditions due to the influence of the long tube in which the radium is housed are taken into consideration, according to the formulæ to be given later, the ratio between the intensities at the two distances is found to be as 1 to 18. Since two hours were required to affect the superficial layers of the tumor, at least thirty-six hours would have been needed to influence the cells on the deeper aspect.

If the law of inverse squares holds accurately, which is the case only when the radium is considered as all gathered at one point, the squares of 1.1 and 6.9 being respectively 1.21 and 47.61, the results should be approximately the larger figure divided by the smaller, or as 1:40. The exposure, therefore, at a distance of 6.9 mm. should be at least forty times as long as at 1.1 mm. As a matter of fact, experiments with 100 mgm. and with 83 mgm. showed that the proportion was about 1:8 or 1:9. This difference is due, as will be shown later, to the fact that when the large tubes containing 100 mgm. of radium were placed over the tissue at *A*, only that portion of the radium which was immediately above the tumor material was effective, whereas when the tube was raised to 6.9 mm. above the tissue, as at *B*, the radium in the extremities of the tube exerted a greater proportional effect than was possible when the tube was only 1.1 mm. distant (Fig. 2). With the smaller tubes of radium the ratio was approximately the same, the proportion being as 1:7.

When the 17 mgm. tube was used unscreened, the proportion as compared to the same quantity fully screened was as 1:110. But little reliance can be placed upon these figures, however, because of the difficulty of determining accurately the death point when using the unscreened tube, consequent upon rapid killing of the tissues, a few minutes more or less introducing a large error, and because of the impossibility of measuring exactly the lethal effect of the various groups

of beta rays which are effective when no screens are used and the distance from the tube is only a few millimetres. Some of the softer beta rays must be extremely destructive, but they are quickly absorbed by the first millimetre of tissue, or even of air.

When a tube is used as in our experiments, and the distance from the tube to the tumor material is small, the radium at the end of the tube is not as effective as that near the middle which is closer to the tissue particle, as has already been said. As a series of exposures, made at distances of 6.9 mm. and 13.8 mm. from a tube 2.8 cm. long containing 83 mgm. of radium element, showed that the time of exposure was

FIG. 2.

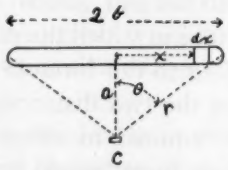

FIG. 3.

less than the theoretical, it was evident that when the tube was more distant from the tissue the radium in the ends became effective. The period required, as found experimentally, was between 2.5 and 3 times at double the distance, instead of the theoretical four times. By simple formulæ, for which the authors are indebted to Professor G. B. Pegram of the Department of Physics, Columbia University, a correction can be obtained as if the radium were all gathered at one point. For those who may be interested the formulæ are given here. The results show that the calculated and observed time for the two distances are very close.

Let length of cylinder of radium $= 2b$,

distance from centre of radium tube (Fig. 3) to tumor cell at $C = a$

and total amount of radium $= Q$

And let intensity of radiation at a point P due to an amount of radium dQ at a distance r from P $= K\frac{dQ}{r^2}$

Neglect the effect of the diameter of the tube, likening it to a line distribution of the radium.

Amount of radium per unit length of tube $= \frac{Q}{2b}$

Amount of radium in length dx of tube $= \frac{Q}{2b}dx$

Then intensity of radiation at C is given by

$$I = \int_{-b}^{b} K \frac{Q}{2b} \frac{dx}{r^2} = \int_{-b}^{b} K \frac{Q}{2b} \frac{dx}{a^2 + x^2}$$

$$= K Q \frac{1}{ab} \tan^{-1} \frac{b}{a} \qquad (1)$$

$$= K Q \frac{1}{ab} \theta$$

Hence:—The intensity of the radiation at C is equal to the intensity of radiation at *unit* distance from an amount at radium $= \frac{Q}{ab} \tan^{-1} \frac{b}{a} = \frac{Q}{ab} \theta$

(θ being expressed in radians)

Further:—The intensities of radiation at two different distances, a_1 and a_2, are in the ratio

$$\frac{I_2}{I_1} = \frac{\frac{1}{a_2} \tan^{-1} \frac{b}{a_2}}{\frac{1}{a_1} \tan^{-1} \frac{b}{a_1}} = \frac{a_1 \theta_2}{a_2 \theta_1} \qquad (2)$$

Calculations by the above formulæ of the effectiveness of the 83 mgm. tube of radium are as follows:—

$$b = 1.4 \text{ cm.}$$
$$a_1 = 0.11 \text{ cm.}$$
$$a_2 = 0.69 \text{ cm.}$$

$$\theta_1 = \tan^{-1} \frac{b}{a_1} = \frac{1.4}{0.11} = 12.7$$

From a table of natural tangents, this is found to be the tangent of 85° 30′, which from a table of angles as radians is found to be equal to 1.49.

In the same way

$$\theta_2 = \frac{1.4}{0.69} = 2 = 63° 26′ = 1.11 \text{ radians.}$$

Then from equation (1)

$$I_{0.11} = \frac{83}{1.4 \times 0.11} \times 1.49 = 803.$$

That is, the intensity of radiation of a tube of radium containing 83 mgm. of element at a distance of 0.11 cm. is equivalent to that of 803 mgm. at a distance of 1 cm.

Similarly:

$$I_{0.69} = \frac{83}{1.4 \times 0.69} \times 1.11 = 95.3.$$

That is, the intensity of radiation of a tube of radium containing 83 mgm. of element at a distance of 0.69 cm. is equivalent to that of 95.3 mgm. at a distance of 1 cm.

The relative intensities are given by equation (2)

$$\frac{I_{0.11}}{I_{0.69}} = \frac{a_{0.69}\,\theta_{0.11}}{a_{0.11}\,\theta_{0.69}} = 1 \text{ to } 8.3$$

As a matter of observation, the 83 mgm. tube kills at 0.11 cm. in one hour and at 0.69 cm. in seven hours, a very satisfactory agreement for biological work.

The relative intensities when the distance from the 83 mgm. tube was 0.69 cm. and 1.38 cm. respectively, are computed as follows:—

$$b = 1.4 \text{ cm.}$$
$$a_1 = 0.69 \text{ cm.}$$
$$a_2 = 1.38 \text{ cm.}$$

$$\theta_{0.69} = \frac{1.4}{0.69} = 63^\circ\,26' = 1.11 \text{ radians}$$

$$\theta_{1.38} = \frac{1.4}{1.38} = 1.014 = 45^\circ\,24' = 0{,}792 \text{ radians}$$

Hence:—The relative intensities are

$$\frac{I_{0.69}}{I_{1.38}} = \frac{1.38 \times 1.11}{0.69 \times 0.792} = \frac{1.5318}{0.5464} = 1 \text{ to } 28$$

a very close agreement with the experimental results.

Some of the tumors which showed growth after the application of either beta or gamma rays were inoculated, together with their controls, into a second and third generation, and in many cases the treated tumors showed a marked slowing in their growth rate as compared with the controls; in some instances, indeed, even up to the sixth generation this change was noticeable, and further investigation may show that a still longer period is required for the tumors to resume their normal rate of growth. The final results will be published in a later paper.

There is some question as to the reason for this slow growth. Probably it is due to injury of the mechanism for mitotic division of the cells, such as Hertwig [7] has demonstrated in the eggs of frogs. The late appearance of the inoculated tumor is not due, in all probability, to small dosage of cells in the implanted fragment, for, if this were the case, the slowing would not be noted in the second or third generation. Stimulation is apparent also in tumors treated with too small doses or for an insufficient time, as Lazarus-Barlow and Beckton [8] found to be the case with Ascaris ova, and as has been so frequently noted clinically. This stimulation is probably effected in two ways: first, by direct action

on the cell mechanism, and, second, by the increased vascularity induced by the inflammatory reaction in and about the malignant growth.

As discontinuous exposures are often necessary in the practical application of radium, experiments were made to see if the sum of a series of exposures was as effective as a single application for the same time. After the lethal dose of radium for continuous treatment had been found, the same amount of exposure was given under exactly the same conditions, but intermittently over twelve and thirty hours, and it was found that the minimal lethal dose was the same whether the treatment was continuous or interrupted. Such short interruptions, however, extending over only thirty hours, would not be of great value in human treatment, for the object of the intervening periods would be only to prevent burning, and this would not be avoided when the interruption covered so short a period as was necessary in our experiments in order to keep the tumor alive. It may be questioned whether intermittent exposures which permit a partial recovery of the cells are ultimately as effective. In treating small subcutaneous nodules in human breast carcinoma, one of us (Wood) has found, for example, that two exposures of four hours two weeks apart were not as efficient as a single one of eight hours. Probably the cells recover in the interval.

In all these experiments, it will be noted, the tissue exposed to the beta radiation must also be affected by the gamma rays, but in the time during which the action takes place such effect must be minimal, as is proved by the results of nearly pure gamma ray exposures. It is perfectly possible to deflect the beta rays with a powerful magnet and allow them to act on tissues without the complicating effect of the gamma rays, as Abbe [9] has suggested, but because, in this method, the beta rays are scattered in a fan-like spray, the total action is much diminished and the time required to produce a lethal effect with the radium available is so great that the tissues could not have been kept alive for a sufficient period even at o° C. Hence, it was impossible to make the experiment.

The question whether the gamma radiation kills by its own direct action or by the formation in the tissues of secondary beta rays has often been discussed, but as it has no practical bearing its investigation was not attempted. That the action is probably due to secondary beta rays and not to primary gamma rays, is the opinion of Rutherford,[10] Keetman and Mayer (*loc. cit.*), Joly, and others, and is suggested, if not proved, by some recent experiments of Abbe (*loc. cit.*). The

ultimate factor may be the chemical action following the ionization produced in the tissues, though, as Wilson's experiments [11] have shown, the ionization is due, not to the direct action of the gamma rays, but to the action of the beta particles which are liberated from the atoms of matter traversed by the gamma rays.

Neither has any attempt been made to verify experimentally the view, so widely held in Germany, that the entire action of the beta rays on the cells depends upon the capacity of these rays to cause ionization, and is consequent upon the destruction of the lecithin of the cells with the separation of cholin, the toxic effect being due to the cholin so set free.[12] According to this view, the effect of radium or X-rays on the cell is entirely dependent upon its lecithin content, and the assumption is made that tumor cells contain more lecithin than normal tissue, an assumption which is quite unwarranted by chemical analyses so far published.

CONCLUSIONS

1. Three factors only are important in the action of radium on tumors: time of exposure, amount of radium element, and distance between the radium tube and the tumor tissue.

2. The removal by suitable filters of the larger part of the beta rays diminishes proportionately the effect of the radium, but the effect of the gamma rays is in accordance with the same general law which governs the beta rays.

3. Sublethal exposures slow the growth of tumor cells for some time, while still shorter treatments seem to stimulate the cellular activities.

4. The facts derived from our experiments regarding the quantity of radium element and the time of exposure necessary for a given distance, may be applied, with reasonable accuracy, to human malignant tumors, the curves shown in Fig. 1 being used as a basis for the estimation. These experiments show also that when only pure gamma rays are used the necessary exposure is eight times as long as that required when the gamma and hard beta rays combined are employed, but as the latter are largely absorbed by 1 cm. of tissue the gamma rays alone must be used for all deep work.

5. The effect of radium radiations on tumor cells *in vitro* is less marked than is that on isolated cellular elements. This explains the fact that an exposure which will destroy a small metastatic nodule in man is quite ineffective in the case of a well vascularized primary carcinoma.

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BOOK REVIEWS

DISEASES OF THE NOSE, THROAT AND EAR, Medical and Surgical. By WILLIAM LINCOLN BALLANGER, M.D., Professor of Otology, Rhinology, and Laryngology, College of Physicians and Surgeons, Department of Medicine, University of Illinois, Chicago. Fourth Edition, Revised and Enlarged. Lea & Febiger: Philadelphia and New York, 1914. Roy. 8vo, 1080 pages.

THIS work is encyclopædic in character and provided with a wealth of illustrations which cover every phase of the text. The previous edition of the work has been favorably reviewed in the ANNALS OF SURGERY so that no elaborate review is again called for. In this new edition a section on the diseases and treatment of the labyrinth, elaborately illustrated and, in all, amounting to several chapters, has been added. A great part of the work has also been entirely rewritten; in some cases with collaboration of other authors. Thus the chapters on vaccines and the His-leucocyte extract for the treatment of various infections, chapters on the functional tests of hearing and on meningitis and brain abscess are in this edition found to have received especial additional attention at the hands of the author and his associates. The recent experience of otologists with salvarsan in syphilitic disease of the acoustic nerve and the brain is fully elaborated in this edition. Though autogenous vaccines for the treatment of hay fever are still on trial, the methods employed by the advocates of this form of therapy are detailed. Operations devised and extensively employed since the last edition of the work appeared have been included, together with the illustrations of the originators of new operations. The work may therefore be said to make good the claim of the author, that "it covers the field."

A MANUAL OF DISEASES OF THE NOSE AND THROAT. By CORNELIUS G. COAKLEY, A.M., M.D., Professor of Laryngology in the College of Physicians and Surgeons, Columbia University. Fifth edition, revised and enlarged. Lea & Febiger: New York and Philadelphia, 1914. 12mo, 615 pages.

THE author of this manual has evidently aimed to dispense with all unessential detail in its preparation, and give in a terse, compact manner a presentation of the art of rhinology and laryngology as he himself

practices it. Thus, instead of an encyclopædic review of the various operations which may be performed for a given condition, the writer has presented only those medicinal and operative measures which, in his judgment, are the best. This method of presentation has been adhered to throughout. This work has, then, this advantage to the beginner and practitioner, that the reader is brought to the clinic of the author, as it were, and as he reads, mentally proceeds step by step with him through the transactions by which the author arrives at a diagnosis and by which he applies the medicinal and operative remedies. By no chance is he confused by any multitude of detail, or by a seeming choice of operative procedures. That the author's method of presenting the subject has been widely approved is shown by the issue of this, the fifth, edition of his work.

A Text-Book of the Diseases of the Nose and Throat. By Jonathan Wright, M.D., Director of the Department of the Laboratories, New York Post-Graduate Medical School and Hospital, and Harmon Smith, M.D., Surgeon to Throat Department of the Manhattan Eye, Ear, Nose and Throat Hospital. Lea & Febiger: Philadelphia and New York, 1914. Roy. 8vo, pp. i–xii, 17–683.

In a review of this work a very few of the apparently most characteristic features which distinguish it from others of its class are herewith unconnectedly detailed. Many of the more useful of the lately-devised and improved instruments and necessaries for the office equipment of the up-to-date specialist, including tables, chairs and new instruments, are described and illustrated with great thoroughness and fulness.

The authors believe the X-ray photograph, as an aid to diagnosis of the diseases of the accessory nasal sinuses, is to be relied upon only as an accessory to other clinical facts. As an operative aid it is valuable in that a side view X-ray photograph outlines the distance between the inner and outer plates of the frontal sinuses and likewise the anteroposterior diameter of the sphenoidal sinus. The authors recommend that two views, *i.e.*, front and side, should both be taken, believing that the anatomical outlines of the sinuses in the individual case thus obtained are useful in every contemplated external operation, for the purpose of fixing the limits and ramifications of the walls of the frontal. We regret that the authors have not included specific directions for the taking of the X-ray photographs. The definition of the relative positions of the X-ray plate and of the head, at the time of exposure of the photo plate, is very important for obtaining the best

results, both in the matter of bringing out the shadows and also for showing the limits of the sinuses.

The portion of the work devoted exclusively to the larynx includes pp. 448 to 544. In this, approximately, 100 pages are included chapters or paragraphs on the gross and minute anatomy, the acute and chronic inflammations, the benign and malignant neoplasms and the operations employed for diseases of the larynx. Much matter on the larynx is also contained in the succeeding chapters devoted to the throat in general diseases, especially those on syphilis and tuberculosis. The word pictures of syphilis of the throat, including primary chancre, the mucous patch, the gumma, differential diagnosis, demonstration of the spirochæta, treatment of laryngeal syphilis and treatment of tertiary syphilis, leave little to be desired, since they cover the field thoroughly; while the graphic style of the authors, especially in this portion of the work, seems, to the reviewer, altogether commendable. Though we would welcome more matter devoted to the treatment of the larynx by the Killian-Jackson direct method, we wish to praise especially the section on the larynx which is, we think, the best in this respect of American text-books of the present period.

WILLIAM C. BRAISLIN.

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ANNALS of SURGERY

A Monthly Review of Surgical Science and Practice

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of New York

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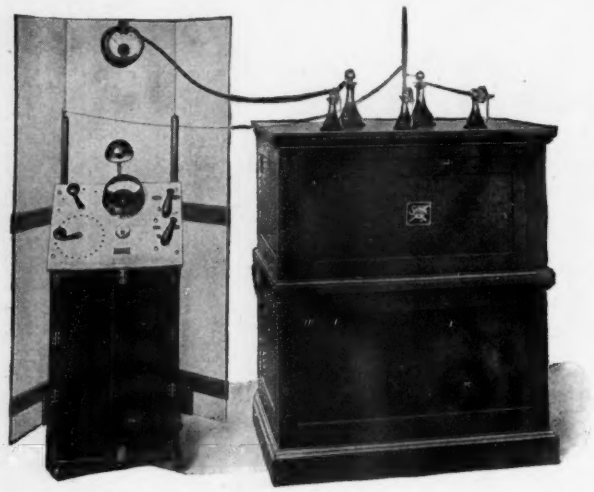

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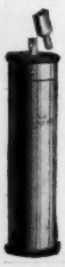

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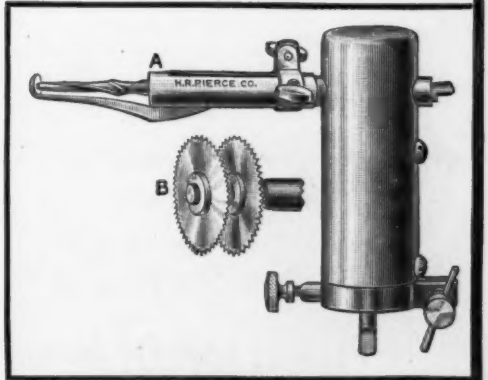

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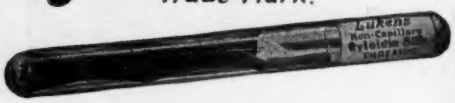

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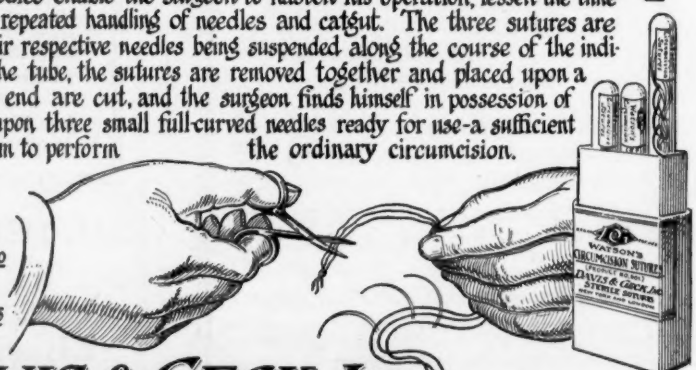

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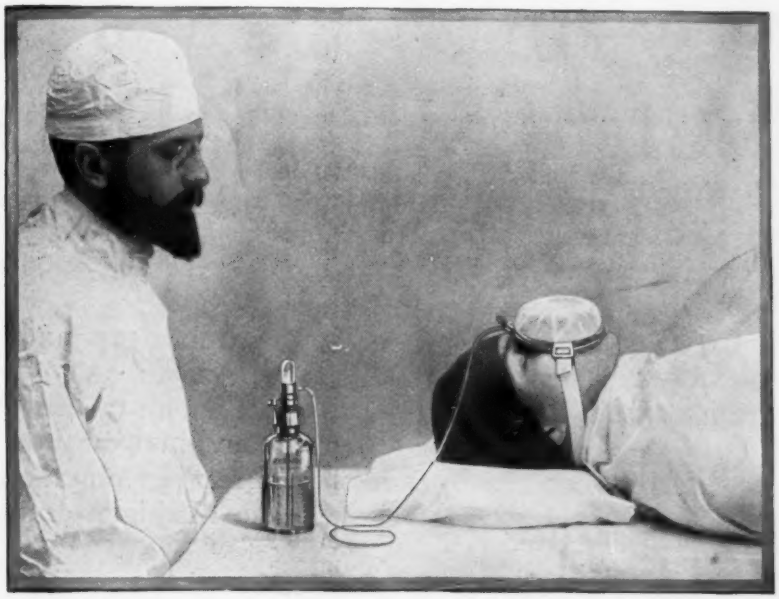

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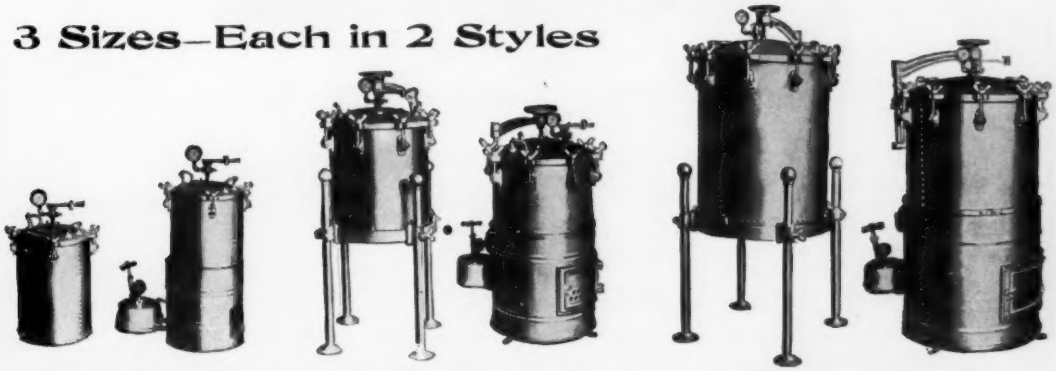

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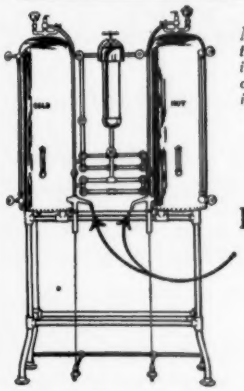

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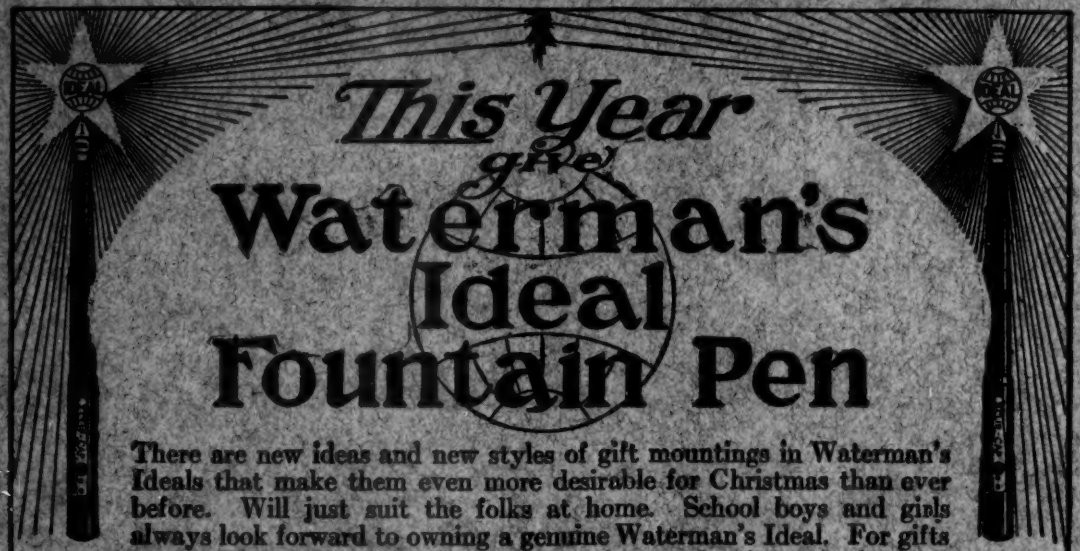

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